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How Engineers Can Use Computers Better

Many design and operating problems are adaptable to computer solution. Simple flowchart of mathematical steps bridges engineer-programmer gap . . . . p. 23

PIPE LINE INDUSTRY

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DECEMBER
1958

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BOOST EFFICIENCIES

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PERSONAL IMPROVEMENT

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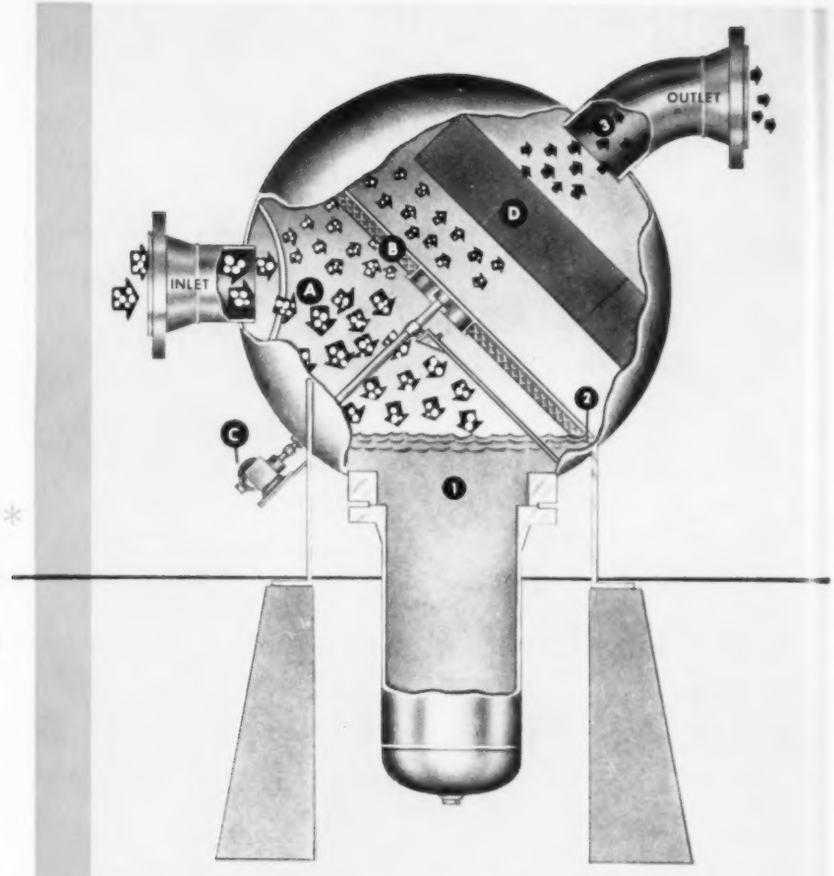
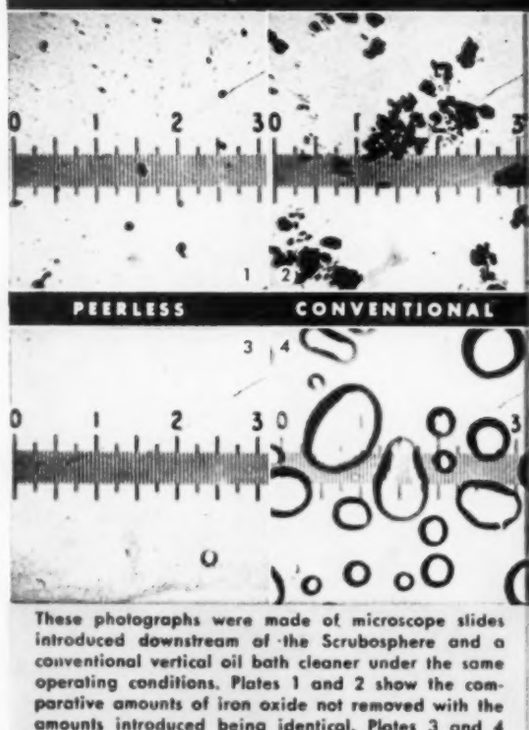


LEGEND OF ABOVE CUTAWAY

The majority of incoming liquid (A) and solid particles are directed to either side and down into reservoir (1). Lighter solid particles carried by gas stream are separated on surfaces of contactor (B) which are kept wet and clean by revolving thru liquid reservoir (2). Contactor is revolved by explosion-proof gear motor (C). Mist Extractor (D) removes any remaining liquid particles from gas stream prior to outlet (3).



These photographs were made of microscope slides introduced downstream of the Scrubosphere and a conventional vertical oil bath cleaner under the same operating conditions. Plates 1 and 2 show the comparative amounts of iron oxide not removed with the amounts introduced being identical. Plates 3 and 4 indicate comparative oil loss with vapor rate through the vessels being the same.

LOOK AT THIS TEST The test at the left indicates the superiority of Peerless Scrubosphere over conventional oil bath dust scrubbers. The SCRUBOSPHERE operates with no loss of efficiency at low flows, minimum liquid loss, and very low pressure drop. Other outstanding features include easy vessel access with removable self cleaning contactor, a sump for slugs of solid or liquid particles, and minimum cost.

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PIPE LINE INDUSTRY

CONTENTS
and Quick Look

December, 1958 gpc Vol. 9, No. 6

To help you put first things first, scan these time-saving digests, checking ☑ those you want to read first.

Predict Performance of Turbo-Engines

☐ Making separate computations to predict the effect of varying conditions on turbocharged engines is time consuming. One solution was to establish a set of curves that can be used to find quickly how any given set of variables will affect turbocharger engine combinations. These curves were computed for turbochargers operating with 2- and 4-cycle diesel engines and with the centrifugal compressor as a driven unit.

Rudolph Birmann and Ernest W. Blattner . . Page 16

Computer Aids for the Pipe Line Engineer

☐ Today's electronic computing equipment has a lot of capabilities not being used fully for solution of pipe line engineering and operating problems. Many engineers need a better understanding of the methods for adapting their problems to computer programming. Flowchart of mathematical processes and symbols can bridge the "mystery gap" between the engineer and programmer. Here is a practical guide to flowchart construction for problems.

By T. R. Young . . . . . Page 23

Alaskan Products Line Operates Year 'Round Despite Temperature Extremes

☐ The 8-inch, 626-mile Haines-Fairbanks military products pipe line is functioning successfully despite the extremes of temperature ranging from 83 degrees below zero recorded at Snag, Yukon Territory of Canada, to a high of 92 degrees at Fairbanks. This pipe line, the northernmost one in the Free World, traverses extremes of altitude ranging up to 3,750 feet. The line is above ground throughout most of its route. Extremes of temperature cause rapid increases and decreases in pressure and flow rates along the line. Despite many problems, the line was operated successfully throughout the winters of 1956-57 and 1957-58.

Dallas B. Pack and H. T. Brundage . . . . . Page 27

Today's Trends in Use of Automation (Part 2)

☐ Results of an industry-wide survey are continued in the second part of this series. Included are use of automatic sequence control, unattended station operation, and present and future use of computers in the pipe line industry. In addition to the number of applications, a summary of the types of installations used is included. Results indicate that computers are already used widely and greater use in future is predicted.

E. B. Turner . . . . . Page 31

Correct Procedures for Field Sampling Gas

☐ Correct methods for taking field samples of gas are essential if laboratory analytical results are to reflect accurately the quality of gas purchased by the pipe line. Here are some worthwhile and practical suggestions that will help avoid contamination, minimize hazards, and insure accurate records. They will help you get representative field samples to the test laboratory.

By Norman E. Watson . . . . . Page 40

Canadian Crude Line Cleaned for Gas Service

☐ To thoroughly clean the interior surface of a crude line before transferring it to gas service, a combination of scrapers and a solvent detergent solution was used. Progress of the cleaning batch through the line was checked by attaching a radioactive source to the lead plug. The rate of flow was controlled to give 10 minutes contact time between the cleaning solution and the pipe wall. Scintillors spaced at intervals indicated a rate of flow of 1 mile per hour.

By R. E. Tschupp . . . . . Page 42

You CAN Write Better Letters

☐ We realize a business letter is not supposed to read like a best selling novel, but there are certain rules you can follow which will make your letters sparkle. Here are those rules—presented in a clear and concise form to help you along the road to becoming a better letter writer . . . . . Page 44

IPE at Tulsa to Feature Pipe Line Advancements

☐ The International Petroleum Exposition May 14-23 in Tulsa will show the numerous advancements in the pipe line industry. For a brief preview of what the show will offer, turn to . . . . . Page 48

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Borden Commission report . . . a serious setback for Canada

A serious blow has been dealt Western Canada gas producers and pipe line companies. Any hopes they might have entertained for early permission to export natural gas has been dispelled as a result of the first report of the Royal Commission on Energy, commonly called the Borden Commission.

The report recommends the establishment of a five-man National Energy Board, which would have sweeping power over oil and gas. Some idea of the proposed scope of the board's authority can be gleaned from the following:

"That the National Energy Board shall have authority to study, review and from time to time recommend to the Minister of Trade and Commerce such policies and measures as it considers necessary or advisable in the public interest for the control, supervision, conservation, use and development of energy and sources of energy and for the production, recovery, manufacture, processing, distribution, transmission, sale, purchase, exchange, disposal, import or export of energy and sources of energy within, to or from Canada."

In view of the foregoing, little comfort is provided by the declaration that exports of Canadian natural gas on a moderate scale are a "highly desirable step," and that it would be unfair to producers to require that "proven reserves be set aside for all long-term future needs of Canada."

This means a long delay before any action can be expected on the granting of export permits. Establishment of such a regulatory body means government study before passing enabling legislation. This could take a year. Then, before the new board could grant export licenses, it would have to review each case on its individual merits. This means another long delay.

Furthermore, since the only possible gas export market is the United States, all applications would have to be aired before the U. S. Federal Power Commission. Here is another delay, and U. S. producers will tell you it means a long delay.

Hopes of producers and pipe line companies that they might gain gas markets through exports of Trans-Canada Pipe Lines Limited also has been dashed by the report. The commission has recommended that the permit promised Trans-Canada in a letter dated September 28, 1955, by the then Minister of Trade and Commerce, for gas export to Tennessee Gas Transmission for resale in the U. S., be "stricken and be considered no longer of any effect." In this connection, the commission recommended that any future application of Trans-Canada for an export license "be considered on its own merits."

This action makes the outlook in Canada uncertain for both producers and pipe lines of crude and natural gas.

Since there can be no hope for any immediate granting of licenses, many Western Canada oil and gas wells will remain shut-in for lack of a market outlook. This will discourage the development of both production and pipe lines.

Furthermore, the possibility that a government agency may be given such sweeping regulatory authority over practically all oil and gas matters will tend to discourage Western Canada development.

If the recommendations of the Borden Commission are followed, Western Canada operations have received a serious setback. Until it is definitely known what course will be followed in the future, both producers and pipe line companies will proceed with caution. This will have a detrimental effect on Canada's supply of oil and gas. By the time conditions are stabilized, Canada may lose some of its oil and gas markets.

Warren L. Baker

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Indexed by Engineering Index

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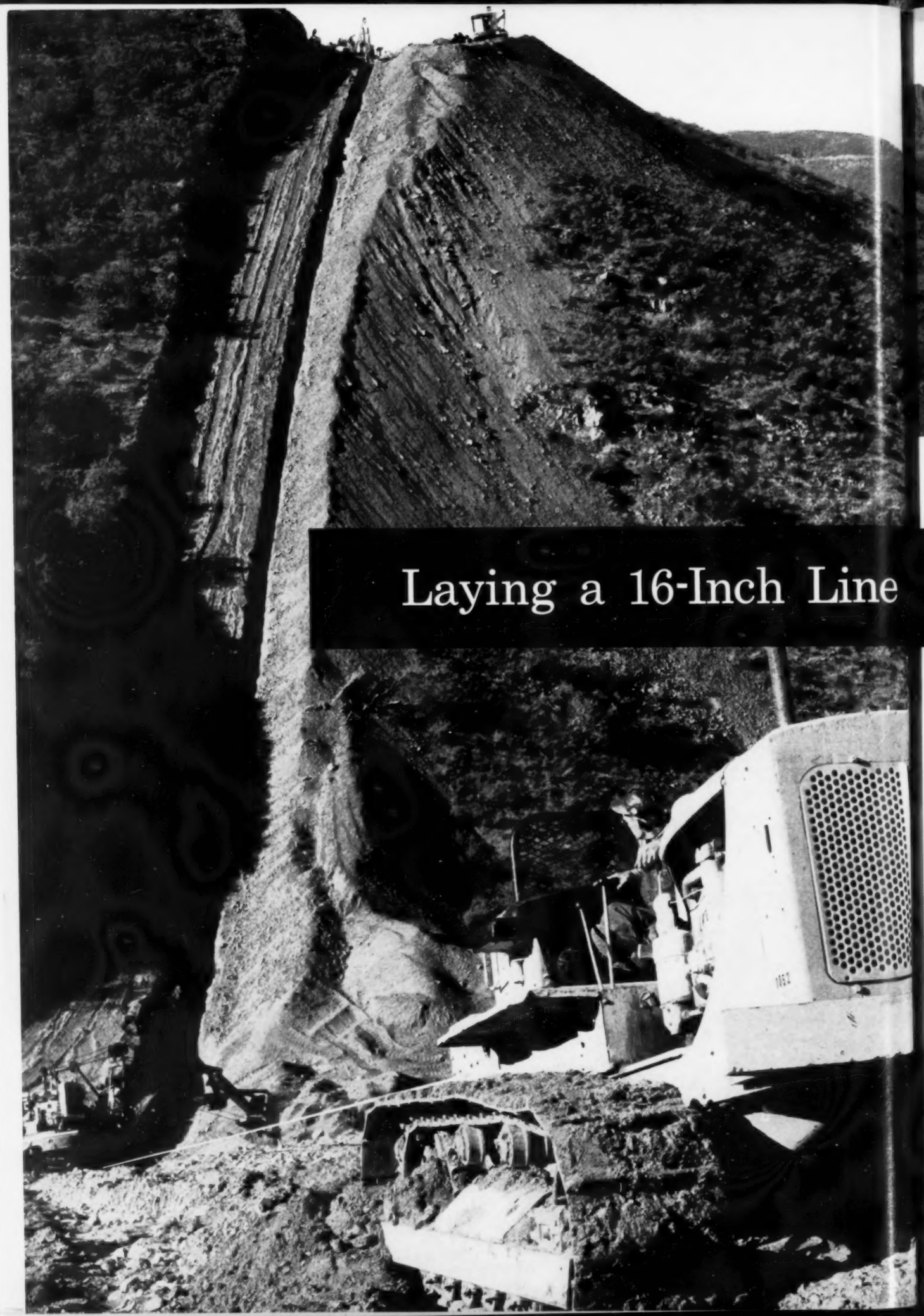

Laying a 16-Inch Line

FIRING LINE — Two MD7s raise the pipe for welding. On the job is a Cat Twin Arc-Welder mounted on a D7 while a D6 pulls another welder mounted on a track wagon.

CAT NO. 583 PIPELAYER AND MD7 with adjustable counterweights team up for R. H. Fulton for doping and wrapping near Twenty Nine Palms, Cal.

ne Practically Straight Up

R. H. Fulton put 165 men and a Caterpillar spread to work on Section 5, where young mountains and 80% slopes had to be crossed

Winching is a standard operation on Section 5, part of a 635-mile crude oil line from Farmington, N. M., to Long Beach, Cal. Experienced pipeliners report that this section has some of the roughest terrain they ever encountered. Using a spread of Caterpillar equipment, R. H. Fulton & Co. is laying 2 miles each 10-hour day on their portion of the line.

A fleet of sure-footed Caterpillar crawler Tractors —D7s, D8s and D9s—are doing the pioneering work. Equipped with bulldozers and rippers, they 'doze a load down one of the steep grades and are pulled back by a D8 with a Hyster winch. The ditcher is pulled up the young mountains by the winch on a D8 and let down the far side.

Filling out the spread on this section are four Cat Twin Arc-Welders, nine Pipelayers and a No. 12 Motor Grader.

On the toughest pipeline jobs throughout the world, Caterpillar yellow is always the predominant color of the equipment. Pipeliners know from field experience that wherever the pipe takes them, Caterpillar equipment will get them through.

CATERPILLAR TRACTOR CO., PEORIA, ILLINOIS, U.S.A.

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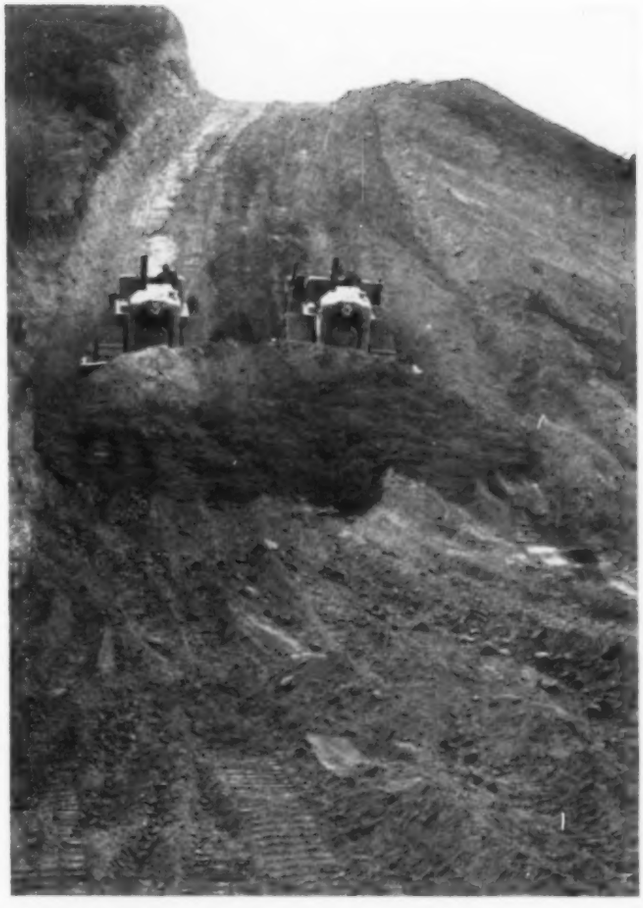


MAN-SIZED PIONEERING — Two giant D9s bulldoze and rip the rocky soil for the ditcher. One D9 is equipped with a Kelley Ripper while the second uses a matching No. 9 Ripper.

A LIFT FROM A D7 — A backhoe is winched up a 75% grade by a D7. Atop the hill in the back are two D8s with a winch and a Caterpillar MD7 with a pneumatic drill.

Tuffy. Tips On

SAFE USE OF SLINGS AND HOIST LINES

Back Injuries and Strains Loom Large in Industrial Accident Picture

Records for recent years in Illinois, as reported by the State Department of Labor, show an average of 8.9% of all compensation cases closed are for back injuries; another 7.4% for strains and overexertion in lifting or lowering. A total of about one in every six claims are for these two categories of injury.

How can we reduce materials handling accidents? The first answer, of course, is not to use human muscle for the heavy lifting jobs that should be done by the proper size hoist, hoist line and slings.

Here are some other answers:

1. **Keep pull** on sling legs in a straight line. Never shorten legs with knots or I-bolts. If choker and basket hitches are used as slings, safe load limits should be rigidly checked.
2. **Load slings** on the center of hooks; never at their points, except for hooks specially designed for point-loading.
3. **Never use** load hooks that are bent open. They have been overloaded, and may drop loads with disastrous results. Same goes for defective chain blocks. Insist that your men report them at once.
4. **Lubricate wire** ropes at regular recommended intervals, with lubricant recommended by your local oil company engineer.
5. **Break in** new wire rope with care. Don't use it as maximum load capacity until it is broken in.

Bad Use of a Good Sling

Here you see a Tuffy Sling in a poor, off balance hook-up. A Tuffy Type U-9, 3 leg bridle Sling would save time and work far more safely than this improvised hitch with unfitted slings and clevises.

Get Safety First With The First Name In Slings... Tuffy.

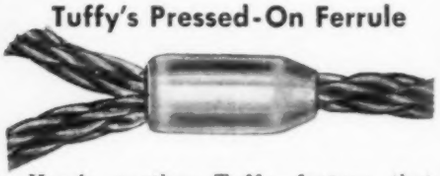
Exclusive Tuffy Fabric

The secret of the extra strength and greater flexibility of Tuffy Slings is also the secret of their greater safety. It's the exclusive, patented, machine-braided fabric. You won't find it in any other machine-made sling. It means longer sling life, easier handling and greater capacity for taking deadloads, shocks and impact with safety.

Try to Kink a Tuffy Sling

It's next to impossible. Even if you do succeed in kinking it with the help of a vise, you can straighten out the sling with no material damage to the fabric. Tuffy's resistance to knotting, kinking and looping is extra protection against hazardous weakening of the sling.

Tuffy's Pressed-On Ferrule



Here's another Tuffy feature that adds safety to longer sling life. Applied under tremendous pressure, the steel ferrule literally flows into spaces between wires and strands—giving the eye-splice *full strength of the fabric.* And the streamlined ferrule eliminates snags and projections that might injure hands.

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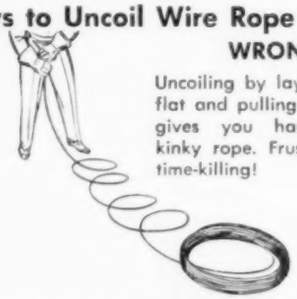
Right and Wrong Ways to Uncoil Wire Rope

RIGHT:

Wire rope in short lengths is furnished in coils. Roll the coil slowly like a wheel and have a nice straight rope before you can say "tuffy."



WRONG:

Uncoiling by laying the coil flat and pulling off the top gives you hard-to-handle, kinky rope. Frustrating and time-killing!

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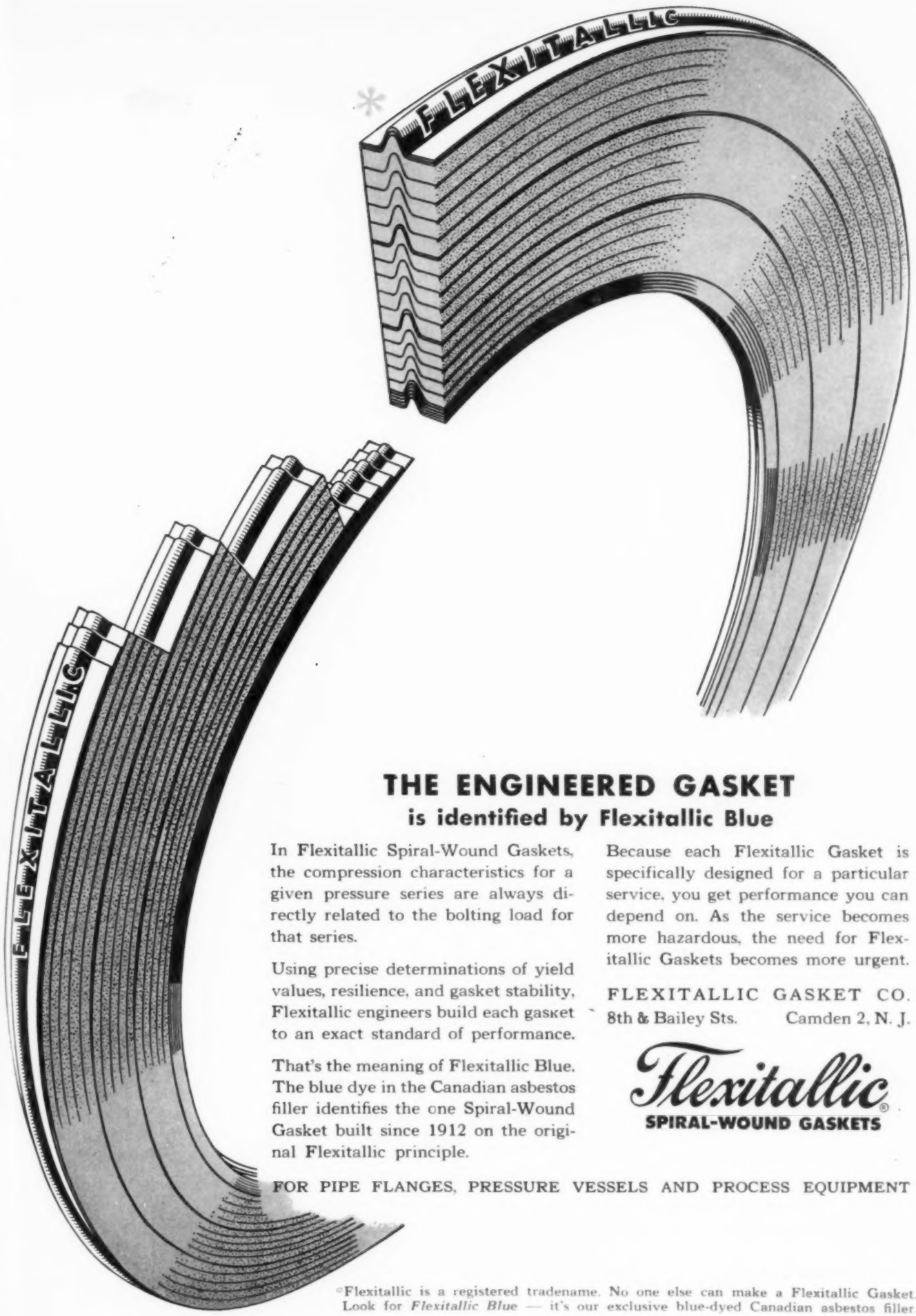

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	SIZES (in., OD)	WALL THICKNESSES (in.)	LENGTHS	SPECIFICATIONS
HYDRAULICALLY EXPANDED ELECTRIC FUSION-WELD (submerged arc)	22 and 24 26 through 36 36 through 42	¼ to .438 incl. ¼ to ⅝ incl. ¼ to ¾ incl.	40-ft (1)	API 5LX, Grades X42, X46, X52 & X56
ELECTRIC RESISTANCE-WELD	5 (nom) to 16	API	to 60-ft	API 5L, Grades A & B API 5LX, Grades X42 & X46
CONTINUOUS BUTT-WELD	½ to 4 (nom)	API	SRL 24 to 26-ft DRL to 50-ft	API 5L
COMPRESSOR STATION PIPE in diameters, thicknesses, and lengths as required.				
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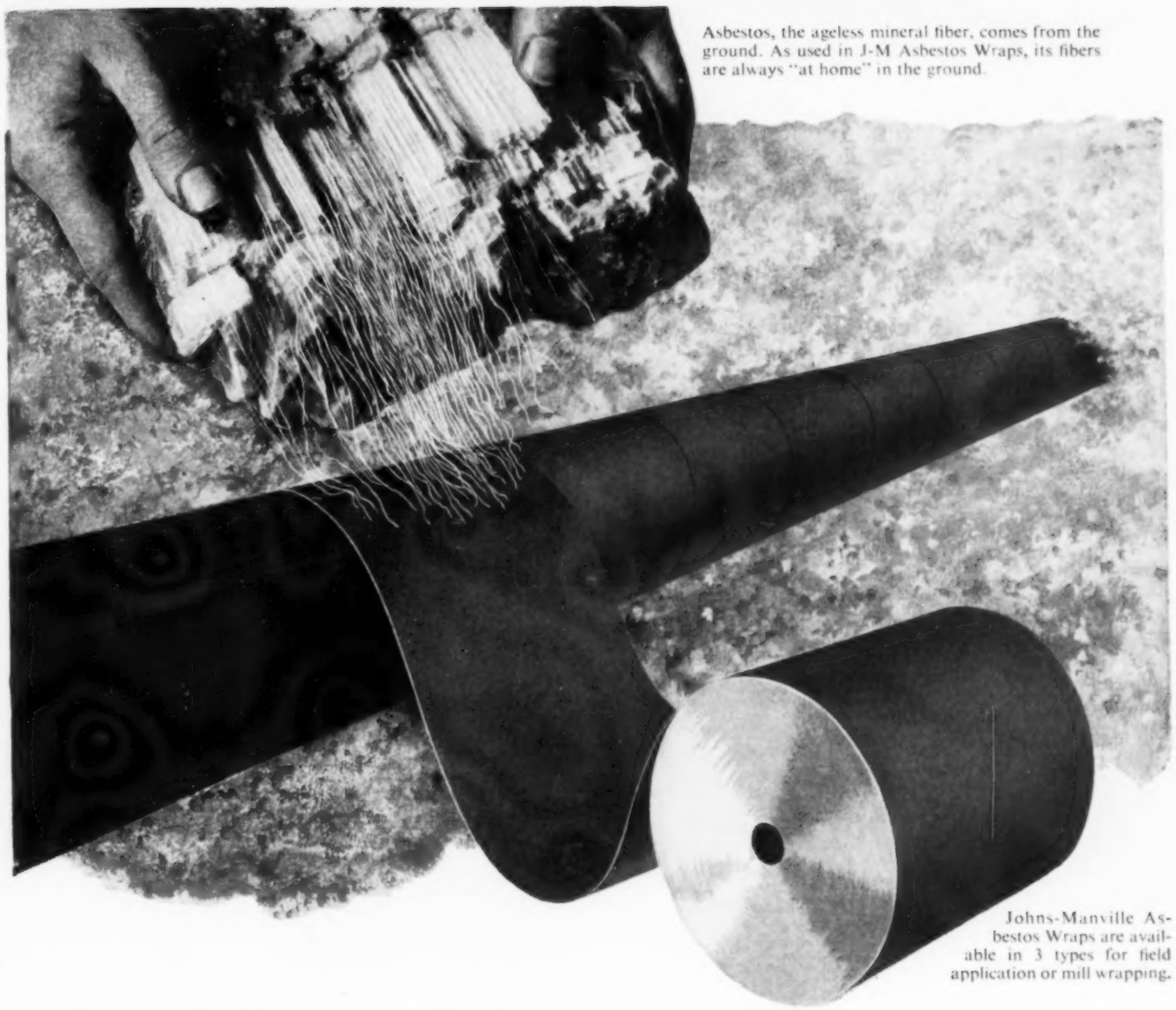
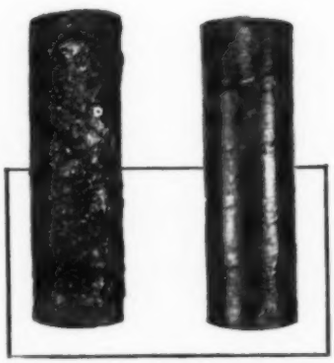


Asbestos, the ageless mineral fiber, comes from the ground. As used in J-M Asbestos Wraps, its fibers are always "at home" in the ground.

Johns-Manville Asbestos Wraps are available in 3 types for field application or mill wrapping.

LIKE WRAPPING YOUR PIPE ENAMELS IN STONE!

. . . J-M Asbestos Wraps
for tough, lasting protection



(Left) Plasticized enamel without J-M Asbestos Wrap did not stand up in soil stress tests. Coating had been applied to 18" sections of 4" O.D. pipe buried in bentonite clay which was then subjected to a series of wetting-downs and dryings.

(Right) Plasticized enamel with J-M Asbestos Wrap shows the full effectiveness of shielding action provided. Sample was in excellent condition after 28 wetting-drying cycles.

Obviously, pure stone can't be fabricated into sheet or roll form for pipeline enamel protection. But you can get the closest thing to it—J-M Asbestos Wrap, made of a lasting mineral fiber that's completely at home underground and uniquely conditioned by nature not to rot or decay.

In addition to being ageless, asbestos fibers are unusually strong and tough. As used in J-M Wraps, the fibers are felted, then impregnated with either coal tar or asphalt saturant to form, virtually, a flexible covering of stone. These "stone-like" qualities provide the durable shielding needed to protect enamels from earth loads, soil movement, other forces which weaken coatings and permit pipe corrosion to set in.

Extensive research and field tests conducted by a leading firm of consulting engineers have demonstrated these long-lasting protective values of J-M Wraps: "Asbestos Wraps offer the most effective single protection against damage—prolong the working life of pipeline enamels."

Pipeline engineers are invited to write for their own copy of this report PP-34A, a *3-Point Study of Pipeline Coatings and Wrappers*, at no cost or obligation.

Johns-Manville, Box 14, New York 16, N. Y. In Canada, Port Credit, Ontario

JOHNS-MANVILLE

MEMO TO
MANAGEMENT MEN
IN THE MAKING:

WHERE THERE'S BUSINESS ACTION THERE'S A BUSINESSPAPER

Some blessings we take for granted. Like ice cubes. Or indoor plumbing. However, older men—wiser men—say a little prayer of thanks for things they know they couldn't do without.

Among these wiser men are the men who make top-level decisions in business.

To make decisions, they must have facts. All the facts. All the pertinent information they can get. And they get a major portion of that information from one unique source: the business publications they subscribe to.

No businessman is fully informed until he reads his businesspaper. He reads it for profit, not for pleasure. He searches it through for news of the trade or industry. For facts. For fresh ideas. For new products he can put to work. And he reads the advertising with the same intense concentration he devotes to the editorial pages.

He knows that his businesspaper is vital to his success—to his very livelihood. And he says a little prayer of thanks.

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PIPE LINE INDUSTRY

One of a series of advertisements prepared by THE ASSOCIATED BUSINESS PUBLICATIONS

PIPE LINE PANORAMA

Borden Report Gets Cool Reaction . . . Midst Borden Report—created uproar over what to do with Canadian gas, Trans-Canada recently completed world's longest pipe line—$375 million, 2,294-mile link between eastern Canada and Western Sedimentary Basin's vast natural gas reserves (estimates up to 300 trillion cubic feet). **Besides throwing Canadian oil and gas operators into a welter of confusion,** Borden recommendations left U. S. applications to import Canadian gas high in the air, i.e., Tennessee Gas' arrangement with Trans-Canada is now in limbo—West Coast Transmission's contract to sell gas to Pacific Northwest was target of critical verbal salvos. Report suggested inquiry to determine why Pacific Northwest got gas for cheaper price than Canadian customers.

Still, Borden Report appears to endorse Canadian gas exports. Canadian oil men fear that delays which will arise if Borden recommendations are accepted might well result in loss of a large portion of gas exports to the United States.

Washington Panorama . . . In annual report to Congress, Attorney General Rogers says time may come when pipe lines should be run independently rather than by majors; two trends were cited: One toward operation of individual lines as connected trunk carriers—the other toward elimination of pipe lines' responsibility to owners for gathering purchases at wellhead . . . **Top gas industry spokesman has warned pipeliners** to beware of federal control of their financing procedures: "Now that pipe line industry is maturing, you must be on your guard, for the FPC, not satisfied with right to impose financing conditions in issuing certificates, wants to acquire direct jurisdiction over security issues" . . . **Democratic sweep in November elections** forewarns tough sledding ahead for depletion provision, new natural gas bill and other important pipe line industry matters . . . **Every segment of the oil industry** is looking hard at Gulf Oil's new philosophy that business should be more active in politics.

Where Pipe Lines Stand in the Automation Era . . . Recent survey shows that 36 percent of product pipe line stations and 20 percent of crude line stations are now remotely controlled. Average horsepower per station: 1,200. Another survey of 48 crude and products pipe line companies (Page 31) indicates increased use of automation. A total of 186 main line stations, 7 main line terminals, 16 tank farms, and 80 gathering systems are unattended. The number of remotely controlled stations on 22 common systems totals 114—an average of 5.2 stations per system.

Free-Piston Engines for Pipe Lines . . . After years of research and testing, free-piston engines for pipe lines are beginning to appear for field service. Iraq Petroleum is installing 3,000 hp free-piston gasifier turbo-pumping unit on Syrian section of its Kirkuk, Iraq to eastern Mediterranean line. National Free-Piston Company has been awarded $420,000 contract to design and manufacture the unit. Also, free-piston engines are being installed in power plant of tanker terminal being built in Bougie, Algeria.

Five Major Gas Line Projects Await Green Light from FPC . . . Outlook for gas pipe line construction in '59 is excellent. In addition to several smaller projects, five major gas line construction jobs now awaiting FPC approval total 3,961 miles of main lines, loops and gathering lines. Cost: $527.3 million.

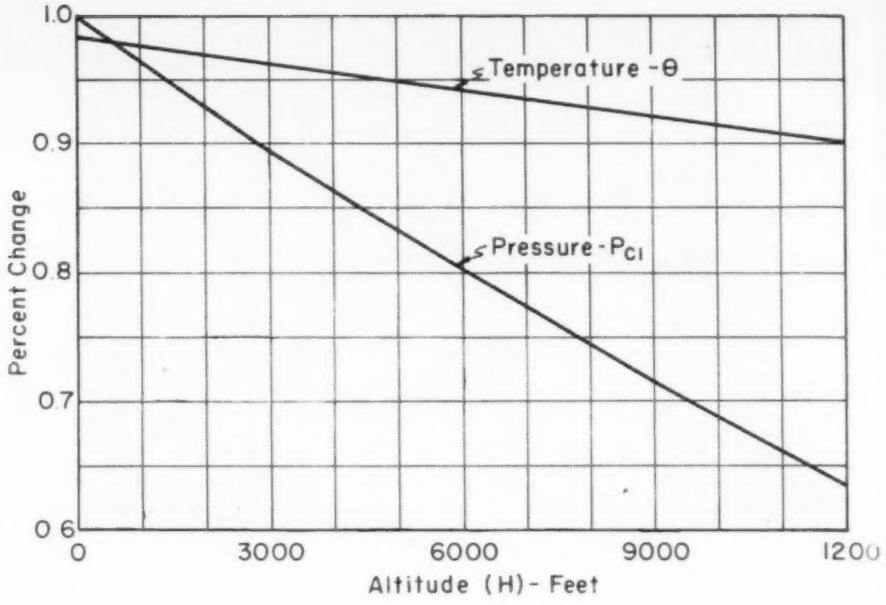


FIGURE 1—Variation of ambient pressure and temperature with altitude. Reference temperature of 68° F (528°R), reference pressure of 14.7 psia.

Predict Performance of Turbo-Engines

Use these curves to predict the effect of changes in ambient temperature, atmospheric pressure, and nozzle area on turbocharger RPM, flow delivery, pressure ratio and other turbocharger characteristics

By Rudolph Birmann and Ernest W. Blattner
De Laval Steam Turbine Company, Trenton, N. J.

MEASURING THE performance of turbocharged internal combustion engines under shop and controlled field-test conditions provides much useful data. Unfortunately, however, these data cannot always be used in trying to predict the performance of engine-turbocharger combinations under the widely varying operating conditions that exist in the field.

For example, what happens when these units are transplanted from sea level to operation at 8,000 feet, or anywhere in between? How will air temperature changes at compressor and engine inlets affect compressor operation? How would you predict the effects on turbocharger rpm, flow delivery, pressure ratio and other characteristics when variables such as ambient temperature, atmospheric pressure, nozzle area and others change?

Series of Curves Provides Solution. Making separate computations for all the varying conditions likely to occur is very time consuming. One solution was to establish a set of curves that could be used to find quickly how any given set of variables will affect turbocharger engine combinations. These curves were computed for turbochargers operating with two- and four-cycle diesel engines, and with the centrifugal compressor as the driven unit.

Analytical Approach Taken. It was assumed that the turbocharger has been reasonably well matched to the engine; at the desired pressure ratio, it operates within the high efficiency range of the compressor, and not too close to the pulsation line. If the turbocharger operating conditions are then changed from those prevailing during the tests, prediction of the effect of these changes by computation requires application of the basic laws of flow and energy balance separately to the compressor, turbine, and engine. It is most desirable to present the results in a non-dimensional fashion, applying to a turbocharger of any flow capacity operating within a wide range of normal pressure ratios. For this reason, a change in any operating condition and the effect of this change should be expressed as a percentage change, (δ). For example,

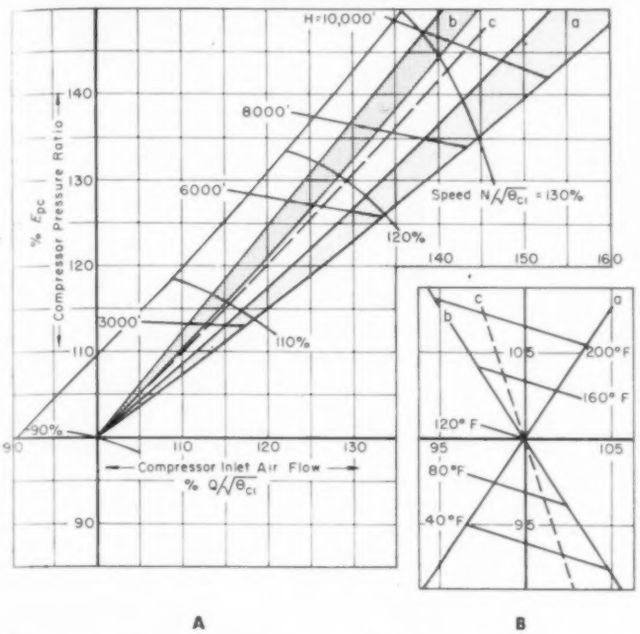
$$\delta P_{C_1} = \frac{P_{C_1} \text{ under changed conditions}}{\text{original } P_{C_1}}$$

$$\delta(Q/\sqrt{\theta}) = \frac{Q/\sqrt{\theta} \text{ under changed conditions}}{\text{original } Q/\sqrt{\theta}}$$

Assumptions Used in Computation. These were the assumptions on which the analysis and computing were to proceed:

1. The turbocharger is well matched to the engine for

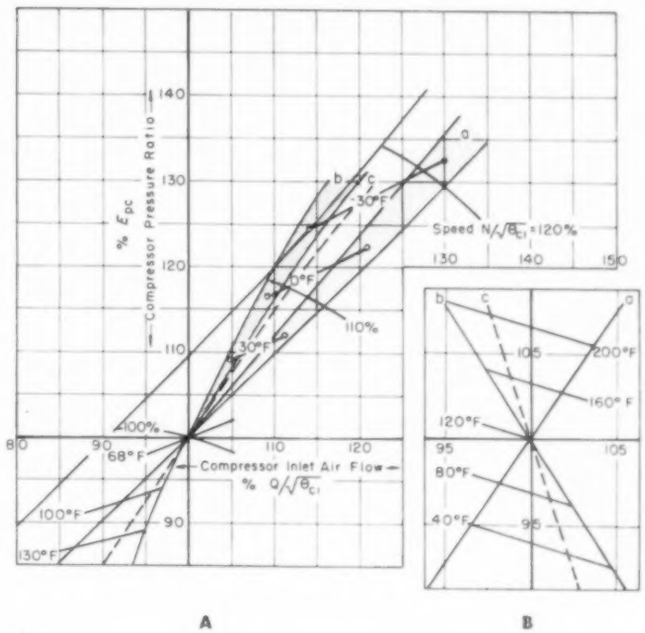
Effect of altitude. For varying inlet engine temperature and altitude superimpose A on B.



A B

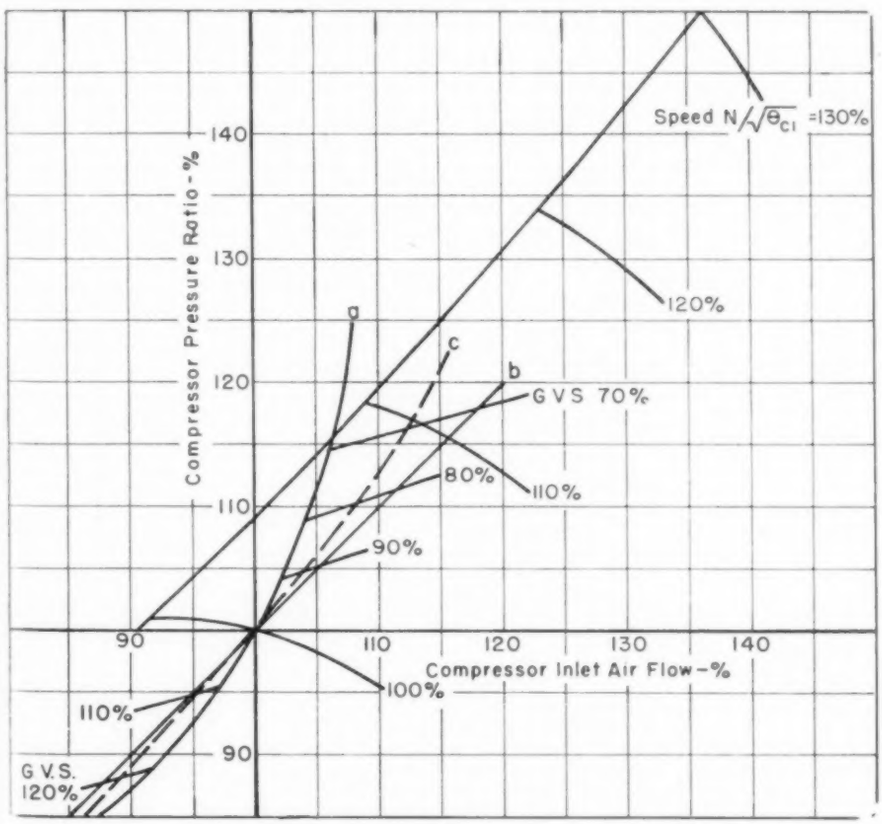
Effect of altitude at constant engine inlet temperature (A). Effect of inlet engine temperature at constant altitude (B).

Effect of air temperature at compressor and engine inlet. For varying compressor and engine inlet temperature superimpose A on B.

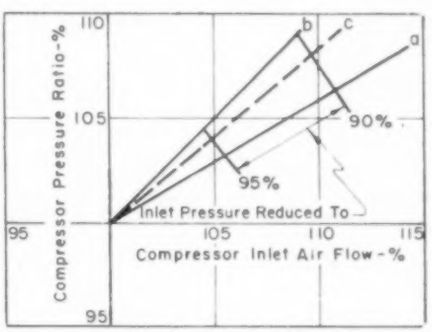


A B

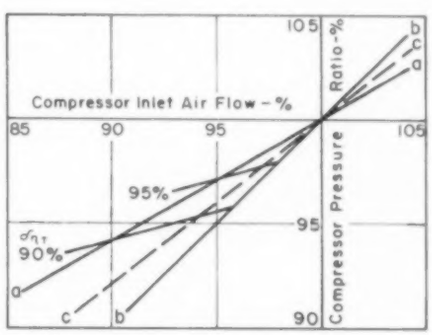
Effect of compressor inlet temperature at constant engine inlet temperature (A). Effect of engine inlet temperature at constant compressor inlet temperature (B).



Effect of turbine nozzle area (G.V.S.)



Effect of compressor inlet pressure.



Effect of turbine efficiency. $\delta\eta T = 90$ percent means turbine efficiency is reduced to 90 percent of its original amount.

FIGURE 2—Effect of variables on compressor operation. Based on constant engine load and speed. Curve (a) for engine with constant K_E (engine equivalent orifice area); 2-cycle engine without blower. Curve (b) for constant engine inlet volume flow; 2-cycle engine with blower and 4-cycle engine without scavenging. Curve (c) for average 4-cycle engine.

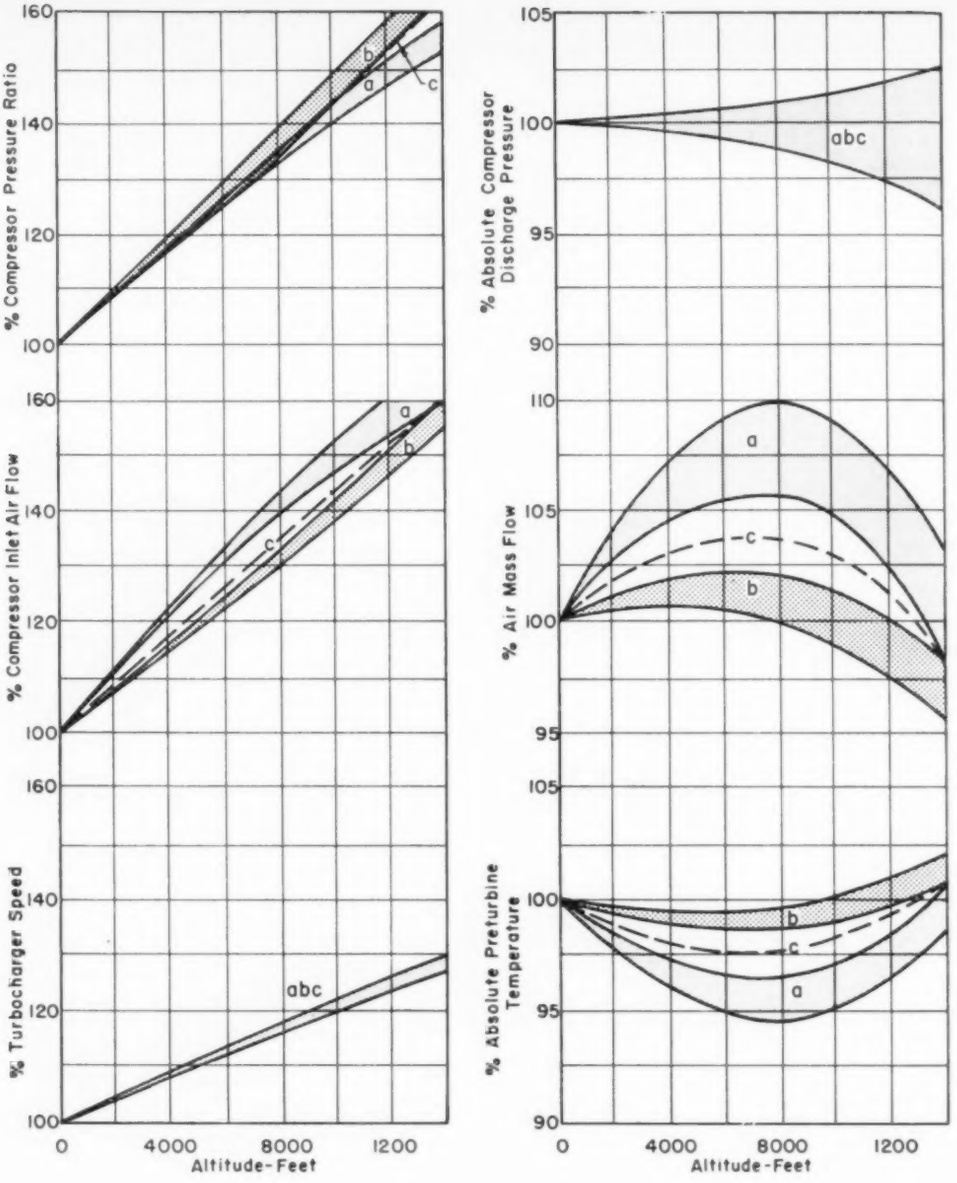


FIGURE 3—Effect of altitude on turbocharger operation. Based on constant engine load, speed and inlet temperature. Curve (a) constant K_E for a two-cycle engine without blower. Curve (b) constant engine inlet volume flow. Curve (c) average four-cycle engine.

standard air conditioning—i.e., the compressor operates at the proper pressure ratio within the high efficiency range, and well within its stable range.

2. The engine load remains constant.

3. The engine rpm remains constant.

4. The heat contained in the engine exhaust is a constant percentage of the fuel heat.

5. The turbine efficiency remains constant.

6. Pressure and temperature at various altitudes change in accordance with curves in Figure 1.

7. Compressor inlet pressure, P_{c_1}, is always equal to the turbine exhaust pressure, P_{T_2}.

Computer Simplifies Calculations. The vast amount of computing involved in working out the curves was accomplished by use of an electronic computer. The trial-and-error method was essential for solving the over-all problem, because equations describing compressor, engine, and turbine behavior are so numerous, and because several of the relationships cannot be written as equations but rather must be presented graphically. In other words, the effects of any new operating conditions, particularly those concerning turbocharger pressure ratio and flow, first had to be assumed and then either verified or corrected on the basis of all simultaneous equations and graphically.

The computation work had to be carried out for the case of a two-cycle engine where the turbocharger is the sole source of air supply, using equation (14), and repeated for the case of a two- or four-cycle engine where the flow through the engine is "metered," using equation (16).

For a typical four-cycle engine which operates with scavenging, it was assumed that the total flow to the engine is composed of 70 percent displacement flow and 30 percent scavenging flow, and the resulting curves have been labeled "average four-cycle engine."

Equations for the Compressor. The air weight flow W is determined by the law of perfect gases

$$W = \frac{P \times Q}{R \times T} \qquad (1)$$

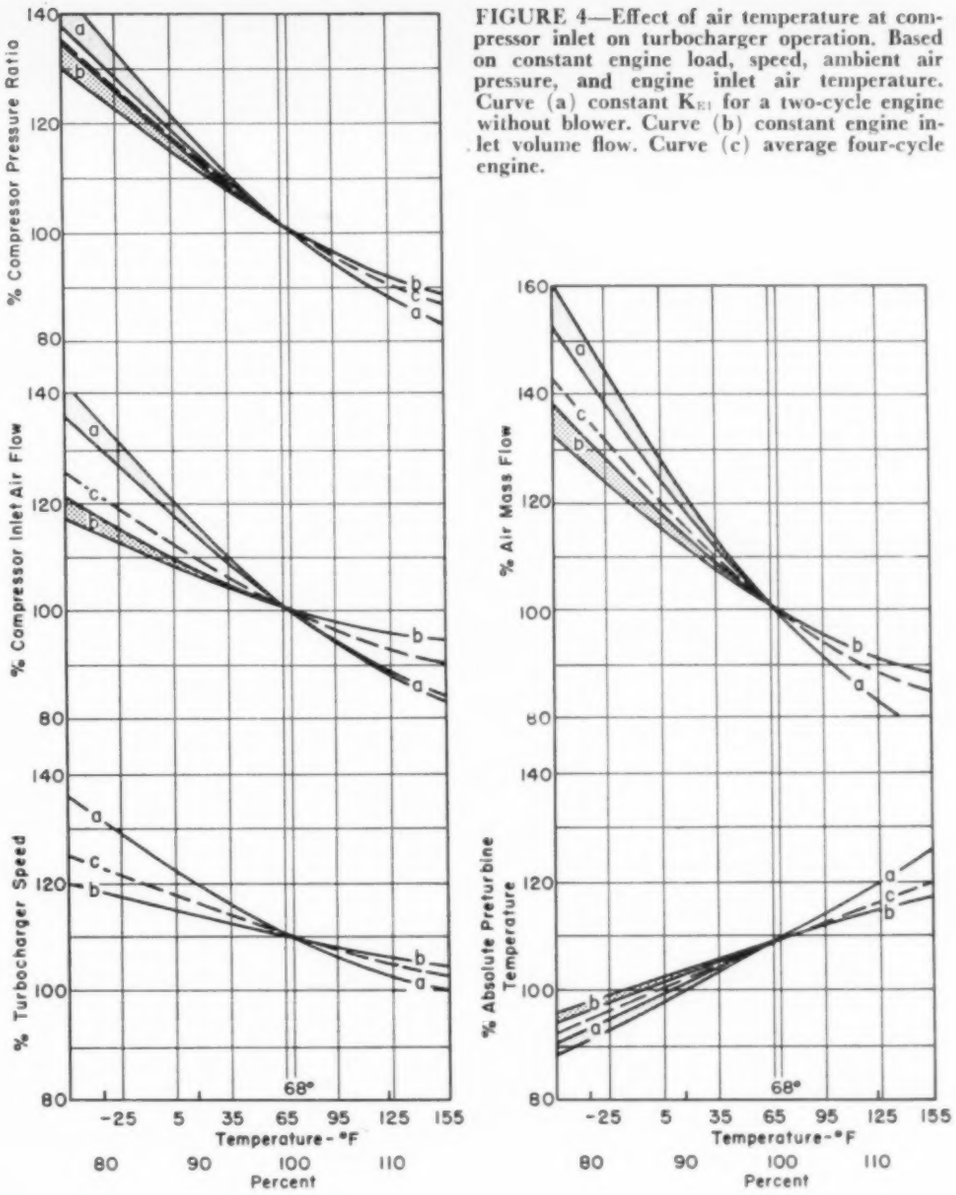


FIGURE 4—Effect of air temperature at compressor inlet on turbocharger operation. Based on constant engine load, speed, ambient air pressure, and engine inlet air temperature. Curve (a) constant K_{E1} for a two-cycle engine without blower. Curve (b) constant engine inlet volume flow. Curve (c) average four-cycle engine.

The air flow through the compressor, reduced to standard air conditions, is:

$$Q_{Co} = \frac{Q_{C1}}{\sqrt{\theta_{C1}}} \times \sqrt{\theta}_{C1} \times \frac{P_{C1} \times T_o}{P_o \times T_{C1}} \qquad (2)$$

where

$$\theta_{C1} = \frac{T_{C1}}{T_o}$$

and therefore

$$\delta Q_{Co} = \delta \left(\frac{Q_{C1}}{\sqrt{\theta_{C1}}} \right) \times \delta P_{C1} \times \frac{1}{\delta \sqrt{\theta_{C1}}} \qquad (3)$$

For the adiabatic enthalpy rise through the compressor:

$$\Delta H_{adC} = C_p \times (T_{C2} - T_{C1}) \qquad (4)$$

or

$$\Delta H_{adC} = \frac{k \times R}{k - 1} \times T_{C1} \times \left[\left(\varepsilon_{pC} \right)^{\frac{k-1}{k}} - 1 \right] \qquad (5)$$

and therefore

$$\delta (\Delta H_{adC}) = \delta \theta_{C1} \times \delta \chi_C \qquad (6)$$

where

$$\chi_C = \left(\varepsilon_{pC} \right)^{\frac{k-1}{k}} - 1$$

For the compressor work input:

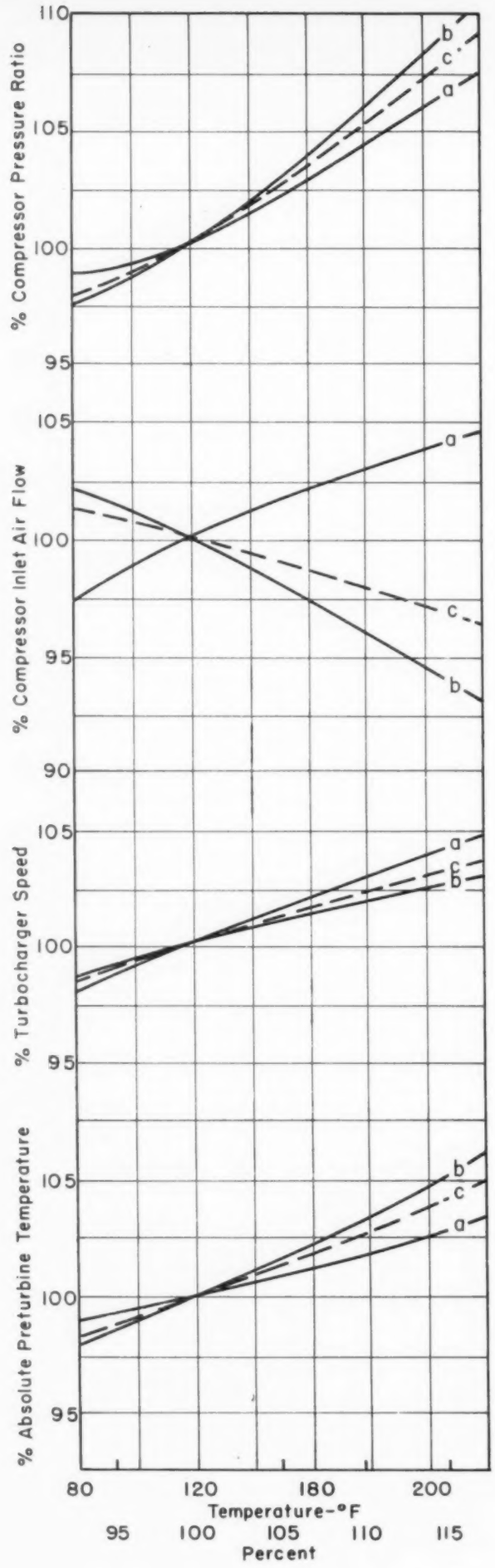
$$P_C = \frac{Q_{Co}}{J_o} \times \Delta H_{adC} \times \frac{1}{\eta_C} \qquad (7)$$

and

$$\delta P_C = \delta Q_{Co} \times \delta (\Delta H_{adC}) \times \frac{1}{\delta \eta_C} \qquad (8)$$

The compressor speed changes with a change in pressure ratio and a change in inlet flow, in a manner which cannot be given by a simple mathematical expression but must be determined from the compressor characteristic curves. Therefore, from the compressor characteristic curves function (9) below can be determined:

$$\delta \left(\frac{N}{\sqrt{\theta_{C1}}} \right) \text{ function of } \delta \varepsilon_{pC},\ \delta \left(\frac{Q_{C1}}{\sqrt{\theta_{C1}}} \right),\ \varepsilon_{pCor},\ Q_{C1or} \qquad (9)$$



The compressor efficiency, for different pressure ratios and different corrected inlet volumes, must also be determined from the compressor calibration chart. Therefore, from the compressor calibration chart function (10) below can be determined:

$$\delta\eta_C = \text{function of } \delta\varepsilon_{pC}, \delta\left(\frac{Q_{C1}}{\sqrt{\Theta_{C1}}}\right), \varepsilon_{pCor}, Q_{C1or} \qquad (10)$$

The inlet air intercooler reduces the compressor discharge temperature, T_{C2}, to the value of the engine inlet temperature, T_{E1} (which determines the specific volume at the engine inlet).

$$\delta T_{E1} = \frac{T_{E1} \text{ in changed conditions}}{\text{original } T_{E1}}$$

T_{E1} is assumed to be an independent variable in the problem, although in some cooling systems it may be affected by the ambient air temperature.

Equations for the Engine. The air flow through the engine is the same as that delivered by the compressor:

$$Q_{Eo} = Q_{Co}$$

and

$$\delta Q_{Eo} = \delta Q_{Co}$$

The flow through the engine depends on the type of engine. In a two-cycle engine for which the turbocharger is the sole source of air supply, the flow through the engine depends predominantly on the pressure drop across the engine. In a four-cycle engine which has no valve overlap and therefore operates without any scavenging, the pressure drop across the engine has no influence on the flow but the pressure and temperature prevailing in the engine inlet manifold are the governing factors.

In a two-cycle engine in which the turbocharger compressor discharges into a positive displacement blower driven by the engine crankshaft, the flow delivered to the engine intake manifold is "metered" by the positive displacement blower. Such metering means that at any constant engine speed the volume flow taken in by the engine cylinders remains constant, so that the mass weight flow depends only on the inlet manifold pressure and temperature, as in the aforementioned non-scavenged four-cycle engine. In four-cycle engines that have provisions for scavenging, the total flow through the engine is composed of two parts: the displacement flow (which is metered in the same manner as described above, and therefore is not influenced by the pressure drop across the engine) and the scavenging flow (which depends on this pressure drop).

For the two-cycle engine in which the turbocharger compressor is the sole source of air supply, the engine acts as an orifice, K_E, and we have

$$Q_{Eo} = \frac{T_o}{P_o} K_E \sqrt{\frac{\Delta P_E}{v_{E1}}} \qquad (11)$$

or

$$Q_{Eo} = \frac{T_o}{P_o} K_E \sqrt{\frac{\Delta P_E \times P_{E1}}{T_{E1}}} \qquad (12)$$

where

$$\Delta P_E = P_{C1}\,\varepsilon_{pC} - P_{T1}$$

FIGURE 5—Effect of engine inlet air temperature on turbocharger operation. Based on constant engine load, speed, and ambient air conditions. Curve (a) constant K_E for a two-cycle engine without blower, Curve (b) constant engine inlet volume flow, Curve (c) average four-cycle engine.

Therefore

$$Q_{Eo} = \frac{T_o}{P_o} K_E \sqrt{\frac{(P_{C1}\,\varepsilon_{pC} - P_{T1}) \times P_{C1} \times \varepsilon_{pC}}{T_{E1}}} \tag{13}$$

and with K_E = constant

$$\delta Q_{Eo} = \sqrt{\frac{\delta(P_{C1}\,\varepsilon_{pC} - P_{T1} \times \delta P_{C1} \times \delta \varepsilon_{pC}}{\delta T_{E1}}} \tag{14}$$

For a four-cycle engine without scavenging or a two-cycle engine equipped with a positive displacement blower arranged between the turbocharger compressor discharge and the engine intake manifold, the following expression applies:

$$Q_{Eo} = \frac{T_o}{P_o} \times K_E{}^1 \times \frac{P_{E1}}{T_{E1}} \tag{15}$$

and with $K_E{}^1$ = constant

$$\delta Q_{Eo} = \frac{\delta P_{C1} \times \delta \varepsilon_{pC}}{\delta T_{E1}} \tag{16}$$

Air flow through the engine and the percentage of the heat in the fuel that is carried away in the exhaust (which according to assumption (4) is constant) are the major factors that determine the temperature rise through the engine. The heat in the exhaust, therefore, is

$$Q_{E2} = Q_{Eo} \times \frac{P_o}{R \times T_o} \times \left[C_p \times (T_{T1} - T_{E1}) + \frac{R}{J} \times T_{T1} \ln \frac{P_{C2}}{P_{T1}} \right] \tag{17}$$

and therefore

$$1 = \delta Q_{Eo} \times \delta \left[C_p \times (T_n - T_{E1}) + \frac{R}{J} \times T_{T1} \times \ln \frac{P_{C2}}{P_{T1}} \right] \tag{18}$$

The term $\frac{R}{J} \times T_{T1} \times \ln \frac{P_{C2}}{P_{T1}}$ is always of very small magnitude and can therefore be neglected, which means that equation (18) can be written

$$1 = \delta Q_{Eo} \times \delta (T_{T1} - T_{E1}) \tag{19}$$

Equations for the Turbine. Considerations of flow balance make it obvious that

$$Q_{To} = Q_{Eo} \tag{20}$$

Flow through the turbine depends on the turbine pressure and temperature conditions and on the nozzle and blade areas. For a very accurate determination of the flow, the individual areas must be known. In addition the exact flow phenomena—particularly the distribution of energy conversion between stationary and rotating blades is required. For the purpose of a general computation the effect of the turbine on the flow can be assumed to be identical with that of a simple orifice which has an equivalent area, A_T. This equivalent orifice area is determined by test measurements made throughout the entire operating range. On the basis of the concept of the equivalent orifice area, the flow through the turbine can be written as

$$Q_{To} = A_T \times \frac{T_o}{P_o} \times \frac{\alpha \times P_{T1}}{\sqrt{T_{T1}}} \tag{21}$$

The coefficient α is the following function of the pressure ratio across the turbine:

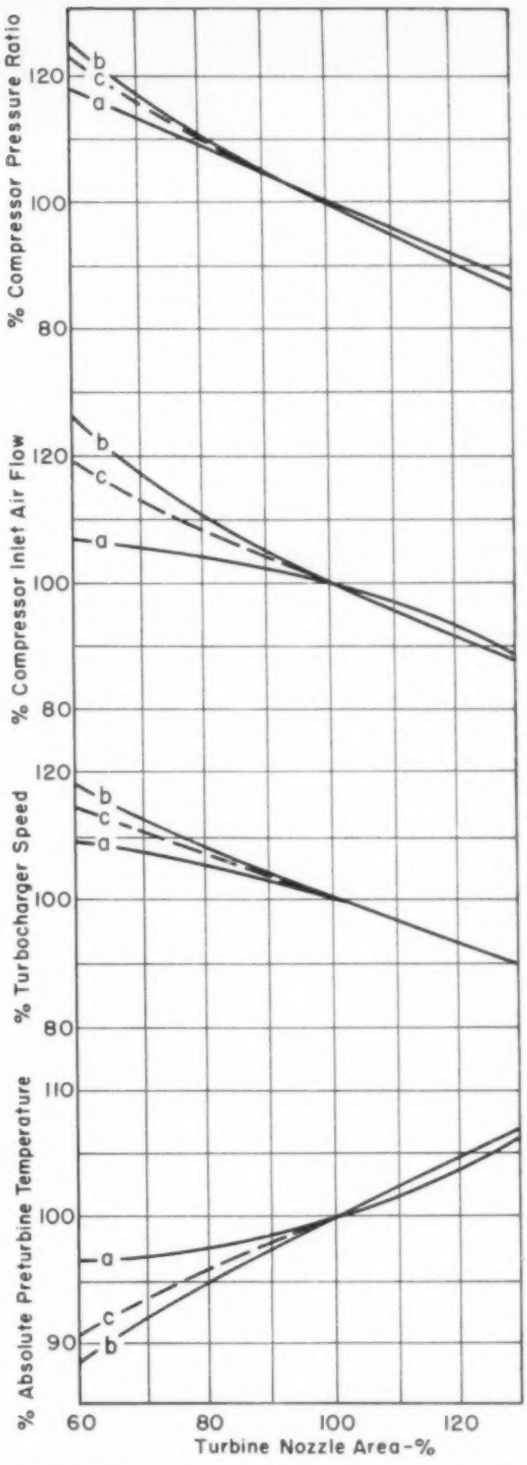


FIGURE 6—Effect of turbine nozzle area on turbocharger operation. Based on constant engine load, speed, and ambient air conditions. Curve (a) constant K_E for a two-cycle engine without blower, Curve (b) constant engine inlet volume flow, Curve (c) average four-cycle engine.

$$\alpha = \sqrt{\left[\left(\frac{P_{T2}}{P_{T1}} \right)^{2/k} - \left(\frac{P_{T2}}{P_{T1}} \right)^{\frac{k+1}{k}} \right] 2 \times g \times \frac{k}{k-1} \times R} \tag{22}$$

In the following range of pressure ratios $-\left(\frac{2}{k+1}\right)^{\frac{k}{k-1}} \geqq \frac{P_{T2}}{P_{T1}} \geqq 0-$ α remains constant, which means that the flow through the turbine depends exclusively on the

About the Authors

Ernest W. Blattner, application engineer for De Laval Steam Turbine Company was graduated from the Swiss Federal Institute of Technology in Zurich in 1953. He worked for three years with Brown, Boveri & Company in the design of large steam turbines. He joined De Laval Steam Turbine Company in 1957 as a member of the turbocharger engineering group. In this group, he participates in the development as well as the application engineering of turbochargers for diesel and gas engines.

Rudolph Birmann, consulting engineer, holds about 75 patents on high-speed turbo machinery. Born in Zurich, Switzerland, Birmann came to the United States after graduation from the Swiss Federal Technical University in 1922. While in charge of turbine design at De Laval he developed the mixed-flow compressor and elastic-fluid centripetal turbine. As founder and chief engineer of Turbo Engineering Corporation, he developed the first American-designed small jet engine. He is a member of ASME, SAE, IAS and American Newcomen Society.

pre-turbine pressure and the pre-turbine temperature, and is not affected by the turbine exhaust pressure.

The equation for the turbine flow variation becomes

$$\delta Q_{T_o} = \delta A_T \times \delta \alpha \times \delta P_{T1} \times \frac{1}{\delta \sqrt{T_{T1}}} \qquad (23)$$

The variation of the equivalent orifice area can be divided into two parts—$\delta A_T = \delta A_{GVS} \times \delta A_N$. δA_{GVS} is an independent variable and introduces the effect of a change in guide vane setting on the equivalent orifice area, and δA_N indicates the effect of the turbocharger speed on the equivalent orifice area.

In any turbocharger the turbine and compressor always operate at the same rpm, and the compressor pressure ratio determines the turbine expansion ratio within very narrow limits, regardless of guide vane setting. For this reason the test results can be plotted as curves of equivalent orifice area vs. guide vane setting, with rpm as parameter, and they can be used in the computation as long as the same definition for A_T is used consistently.

The adiabatic head of the turbine is expressed by the equation

$$\Delta H_{adT} = -\frac{k \times R}{k-1} \times T_{T1} \times \left[\left(\frac{P_{T2}}{P_{T1}}\right)^{\frac{k-1}{k}} - 1\right] \qquad (24)$$

and

$$\delta(\Delta H_{adT}) = \delta T_{T1} \times \delta\left[\left(\frac{P_{T2}}{P_{T1}}\right)^{\frac{k-1}{k}} - 1\right] \qquad (25)$$

The turbine output then is

$$P_T = \frac{Q_{Eo}}{v_o} \times \Delta H_{adT} \times \eta_T \qquad (26)$$

and

$$\delta P_T = \delta Q_{Eo} \times \delta(\Delta H_{adT}) \times \delta \eta_T \qquad (27)$$

Since the turbine output must be equal to the power required to drive the compressor plus the mechanical losses in the bearings,

$$P_C = \eta_m \times P_T \qquad (28)$$

With η_m = constant,

$$\delta P_C = \delta P_T \qquad (29)$$

Test Results Agree with Analysis. The theoretical analysis was undertaken because even the engine manufacturer (who alone is in a position to explore these problems, for reasons of both time and money) could not possibly carry out the experimental work needed to obtain complete knowledge of the interaction of various turbocharger-engine combinations for the full possible range of guide vane settings, ambient temperatures, turbocharger inlet pressures, and inlet manifold temperatures.

Nevertheless, the course of normal engine testing by manufacturers does provide fragmentary test results that can be used for comparison with the theoretical computations. These results are shown as crosses on the corresponding curves. All the points plotted were obtained under conditions of constant engine inlet volume flow, and therefore are to be compared with the curves labeled "b."

Note that the test results agree reasonably well with the theoretical analysis results. The "scatter" of the test points (which occurs even in tests of one particular engine) is probably due to measuring inaccuracy that is unavoidable in routine testing. Moreover, it must be remembered that certain simplifications were made for the purpose of this analysis, including assumption of constant turbine efficiency, disregard of any dynamic effects of the flow into, through, and out of the engine, and variations in these effects as operating conditions change. In view of these factors the reasonably good agreement between practical and theoretical testing is gratifying.

On the basis of the evidence, there is every reason to believe that the curves presented here are valuable tools for predicting the behavior of a turbocharger under varying operating conditions. —**The End**

EXPLANATION OF SYMBOLS

- P — pressure
- Δ P — pressure drop
- Q — volume flow, cu.ft./min.
- Θ — ratio of absolute temperatures, T/T_o
- $Q/\sqrt{\Theta}$ — temperature-corrected volume flow, cfm
- δ — variation of the term which follows immediately, in particular, the ratio $\frac{\text{amount in changed conditions}}{\text{original amount}}$
- W — weight flow, lb./min.
- v — specific volume, cu.ft./lb.
- R — gas constant, ft.lb./lb. °R
- T — absolute temperature, °R
- J — thermal energy equivalent, 778 ft.lb. Btu
- Δ H — head, Btu/lb.
- c_p — specific heat added under constant pressure, Btu/lb. °R
- c_v — specific heat added under constant specific volume, Btu/lb. °R
- k — adiabatic exponent, non-dimensional
- X — adiabatic pressure function
- P — work
- η — isentropic efficiency
- N — speed, RPM
- ε — ratio, particularly ε_p = pressure ratio
- K — nozzle constant
- A — equivalent orifice area

SUBSCRIPTS

- C — compressor
- E — engine
- T — turbine
- o — at standard conditions
- or — at original operating conditions
- 1 — inlet
- 2 — discharge
- ad — adiabatic
- m — mechanical
- p — pressure
- GVS — guide vane setting
- N — speed

PART 1

Computer Aids For the Pipe Line Engineer

Engineers need at least a basic understanding of the methods for adapting the problem to the computer. Here is a practical step-by-step guide

By **T. R. Young**
Shell Pipe Line Corporation, Houston

THIS ARTICLE describes the flowchart method for defining technical computation work intended for electronic calculation. The flowchart is an excellent introduction to practical use of the stored program computer; it can be used effectively by any engineer using the services of a central computing staff. He does not have to learn programming to use it.

The computing art today is considerably advanced over that of only a few years past. Stored program computers have greatly increased the ease of programming by computing personnel.

While advances were being made in computing hardware and techniques other research work was bearing fruit in the form of new mathematical accomplishments. New techniques include queuing theory, game theory, several optimization techniques, and the Monte Carlo method for handling statistics as an element in projections.

Operational Gaming Simulates Business. Operational gaming is making its appearance as a powerful device for the simulation of business operations. Today it offers the opportunity of training managers in a higher level of decision making; in effect, exposing them to the hazards of advanced management decision making with none of the hard consequences of real decisions made in error. The operational game today is suitable for training of executives—tomorrow, through further development, it will provide a tool for policy development and eventual management decision processes.

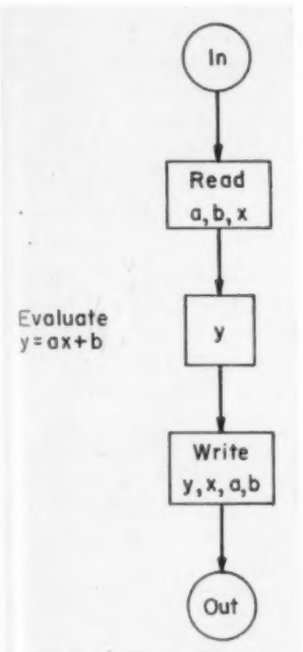


FIGURE 1 (left)—A basic flow chart for computer programming shows the flow of data and computation steps by symbols.

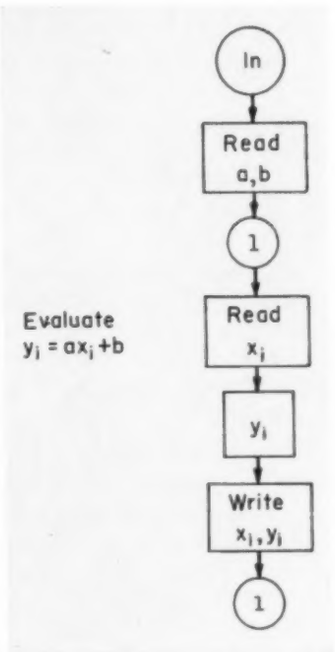


FIGURE 2 (right)—An enlargement of the computer programming is needed where a family of x values produce a family of associated y values.

Where Does the Engineer Stand? These advances in hardware and technique have gotten ahead of the general engineer—largely because of poor communications between the computing community and their colleagues in practical engineering work. The first gap in understanding developed with the early introduction of mathematical notation as a means of communication among computing specialists. Some of the technique of such communication, essential to the computing specialist, lay outside the background of the general engineer. Moreover, the extended jargon associated with computers themselves produced another gap in understanding between the general engineer and the computing specialist.

Gaps in communication have widened until today the engineer with the traditional background feels somewhat baffled and, perhaps, even excluded from the community of computer users because of such barriers.

This barrier to understanding and free flow of information between general engineers and the computing group constitutes one of the neglected problem areas in computer exploitation.

Breaking Through the "Mystery Curtain." It is the purpose of this article to reduce this communication barrier through an exact description of one of the important and nearly universal tools used by the computing specialist. The technique to be discussed is the preparation of flow charts for the complete description of problems intended for automatic solution by a stored program computer.

The Flowchart. A flowchart may be considered the best descriptive device for visualizing the stored program computer and its use. Methods of flowcharting are applicable to small computers as well as to the largest scale machines available.

Flowcharts are one of the basic divisions of computation program preparation. Usual steps in the preparation of a problem for automatic solution are (a) the mathematical statement (b) the flowchart and (c) program coding and check-out.

The mathematical statement contains all of the static relationships among variables that are to be recognized. It establishes the basic structure of the problem solution. However, the mathematical statement usually fails to state explicitly the sequence of computation and the range of variables to be examined. Although this later information is usually found by a close inspection of the mathematical statement, it is often desirable to prepare an explicit statement of this information. This job is handled by the flowchart.

In addition to supplementing the mathematical statement, the flowchart sets forth the exact logical structure of the program. The logical structure defines the various alternative routes of computation that may be required in the problem solution; it also defines the criteria for selection of the alternative routes of calculation.

Study of flowcharting methods is probably the best first step in the education of engineers in computer usage. Effort expended in studying flowcharting should yield greater dividends in the understanding of stored program computation than any other subject of initial study.

Data Identification. Certain conventions used by mathematicians are particularly useful in handling the large masses of data which necessarily characterize automatic computation. Most of these conventions are probably familiar to the engineer, but a few of them will be reviewed briefly here to simplify further discussion.

A notation x_i is used to designate a particular value of x, specifically, the *i*th value. The notation $i = 1(1)n$ associated with the expression x_i indicates that values of x_i ranging from x_1 through x_n are under consideration. Similarly, the notation $[x]_i$ designates the entire set of x_i values and, again, the notation $i = 1(1)n$, specifies the range of the values for x_i under consideration.

Notations $[x]_i$ $[y]_i$, $[z]_i$, designate sets of all values of x_i, y_i and z_i. A set of parameters carrying the same subscript will be interpreted as linked with respect to i. In other words, if the i value for x is 10, meaning the 10th value of x, then associated values for y and z will also be understood to be the 10th values of their sets.

Notations $[x]_i$, $[y]_j$, $[z]_k$ specify three sets of variables, x_i, y_j and z_k for which disassociated reference may be made. In other words, if i had the value of 10, indicating the 10th value of x_i, j and k may have any other desired values permitting independent referencing of y_j and z_k relative to x.

Subscripts play an important part in the identification and modification of values to be substituted for variables in the computational operation. For this reason it is desirable to avoid the use of subscripts for purely primary identification. More specifically, if a given parameter is not subject to repeated substitution, it is desirable to use such identifications as x, x*, x′, x″ for differentiation among closely associated variables.

The notation $[a]_{i,j}$ designates all values of a_i for each of all possible j values. Thus, a two dimensional array of data can be fully designated by this notation. In physical terms, if i should be taken as the column identification of a tabular set of data and j should be taken as the line identification, the notation $[a]_{i,j}$ would indicate the entire array of data contained in the table.

Another useful convention for referencing specific pairs of values for variables is that used in recursive notation. For example, a_{i-1} is recognized as the value preceding that of a_i. Similarly, a_{i-2} is recognized as the second value following that of a_i.

Input/Output and Computation Symbols. As an introductory use for some of the symbols used in flowchart construction take the problem of evaluating $y = ax + b$ for which single values for a, x, and b are given.

The start of the program is designated by the symbol "IN" and is followed with a data read operation contained in a rectangular box (see Figure 1). This operation makes available all necessary data for computation of y. Computation itself is specified by simply writing y in a box. This is interpreted by the programmer as requiring the computation of y. The computation is completed; y is written out along with identifying values for x, a and b as specified in another box containing a write instruction. The calculation, of course, is trivial.

Testing, Branching and Looping. An enlargement of the program involves computation using a family of x values producing a family of associated y values (Figure 2). For simplicity, the same function is used, this time writing $y_i = ax_i + b$, for $i = 1(1)100$. This is read as a specification for computation of 100 values of y, each determined by a particular value of x over the range of x_1 through x_{100}.

Again computation is initiated and followed by a read instruction, this time covering only the fixed co-efficients a and b. It is quite often convenient to separate the fixed data, which are constant throughout a computation, from the variable data which assume successive values.

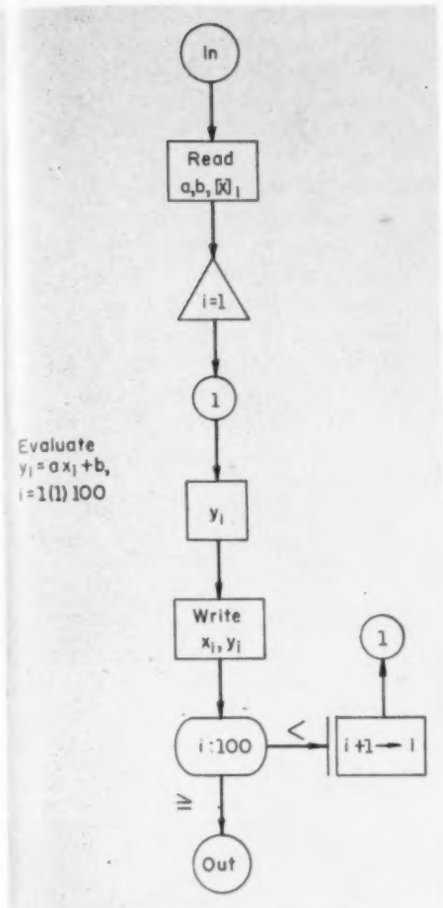
Suppose that a deck of cards containing x_i values are sitting in the read hopper of the computer, therefore a read function is specified for the first x_i value, i.e. x_1. The next step is to specify computation of the y_i value. Again this requires writing of output data, the y_i value plus the identifying x_i value. At this point the computation of the first y_i value, i.e. y_1 has been completed.

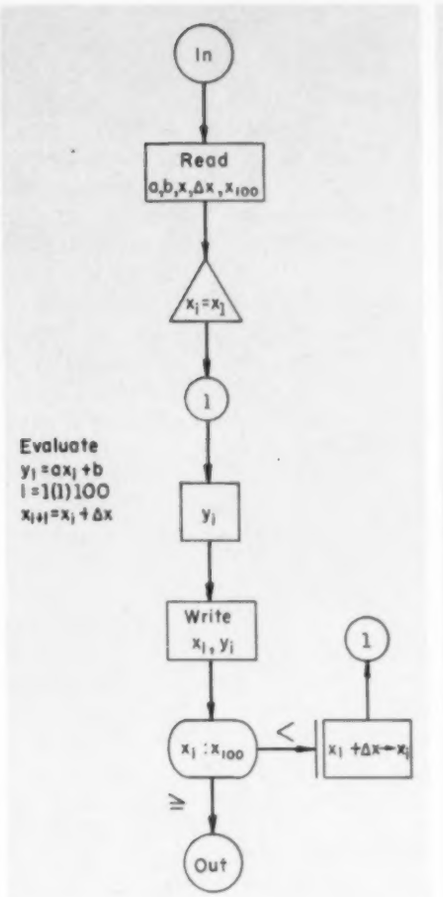
All of the computation specifications have been written previously for repeating this operation. The only thing required is a device for signaling a repeat for reading another x_i value, with subsequent computation and writing. This is done by simply drawing an arrow to a circled "1."

The circled "1" is called a fixed connector and designates a point in the flowchart to which a return is desired. In this case a return to the read instruction for x_i is desired, therefore the fixed connector, 1, is placed immediately preceding the read x_i instruction.

With completion of the flowchart, full specification has been made for computation of 100 values of y_i based on successive values for x_i. The process will continue until all x_i values have been read and all y_i values have been computed; it is terminated by exhaustion of the supply of x_i data.

Test for Complete Computation. This computation





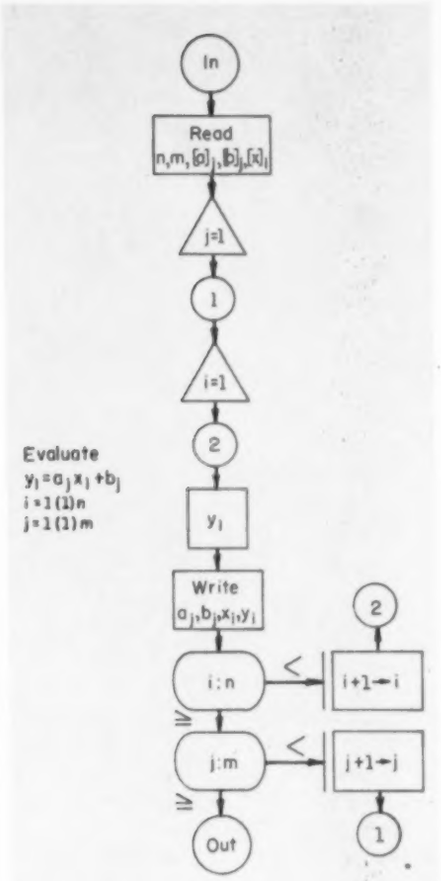


FIGURE 3 (left)—Since flow chart structure is frequently used for repetitive reading of data, a more exact specification of desired computation is symbolized here.

FIGURE 4 (center)—Where the set of variable values is systematically related, input data can be handled most conveniently by computing successive values for the input variable x_i.

FIGURE 5 (right)—For several variables where nested loops are used for computation, various subscripts can be simultaneously operative and specified for the flow chart.

scheme has some ambiguity in that no control is obtained on the number of x_i values read and computed. However, flowchart structure is frequently used for repetitive reading of data. A more exact specification of the desired computation, including a change in the data read plan is symbolized in Figure 3.

The first operation is a "read" for all data required a, b, and $[x]_1$. This "read" instruction includes values of x_i to be used in the computation. As all x_i values are immediately available for computation, some identification for the first value to be used is needed. This may be shown by an initialization, commonly given in a triangle, where the value for i is assigned a value.

Having identified the first piece of data to be used, the calculation of y_i is specified as before; it is followed with a "write" instruction. To establish the fact that 100 and only 100 values of x_i will be used in the computation, it is necessary to write a test and branch on the value of i at this point. The test is expressed by writing i:100 within an oval box. Two branches lead from the box, each labeled with a magnitude comparison sign. The box may be read: Compare i with 100 and take the "less than" branch if i is less than 100, and take the "equals to or greater than" branch if i is equal to or greater than 100.

Next Value Selected. In the first passage through this test, the value of i will be 1, as initialized. The test exit will be the "less than" branch. Selection of the next value for x_i is done by writing a modification, $i + 1 \rightarrow i$, placed in a rectangular box with a double bar on the left hand side. Read: i + 1 becomes i. This is interpreted as a request to select the next value of x_i after the one immediately used. This is followed by a return to the computation of y_i and the fixed connector 1 is installed at that point.

On the 100th passage through the test and branch, i will be equal to 100 and the "equal to or greater than" branch from the test will be followed and computation will be concluded.

Magnetic Memory Capacity Important. It should be noted that in this second evaluation for the y_i series, sufficient magnetic memory was required to store not only the co-efficients in the equation, but also the 100 values of x_i. Quite often the magnitude of such bulk storage requirements exceeds the computer memory, so the programmer is forced into the first type of data read plan based on successive data reads. The engineer preparing computation specification in flowchart form should consult with his computing staff for information on this restriction.

Generation of Input Data. The previous problem handled a simple linear equation evaluation in a way which permitted arbitrary values for the set of x_i values.

Quite often, however, the set of variable values will be systematically related. For example, the values of x_i may take successive values as 10, 20, 30, 40, ... 1,000.

This type of input data can be handled most conveniently by computing the successive values for the input variable x_i. Flowchart specifications would contain initially (Figure 4) a read instruction calling for the coefficients a, b, x_1, x_{100} and Δx, where Δx is the increment between successive values of x_i. Initialization can be expressed as before, $i = 1$ or, alternatively $x_i = x_1$.

Computation of y_i and writing of output is identical with the previous flowchart. However, the test for conclusion of computation is expressed by a test of x_i against x_{100}. On the first passage through the computation, x_i will be equal to x_1 and less than x_{100}. The computation route will follow the "less than branch" and lead to a modification calling for the incrementing of x_i by Δx. A return to the computation of y_i via the fixed connector 1 follows. On the 100th execution of a y_i calculation, x_i will equal x_{100} and the test will branch through the "equals to or greater than" exit, concluding the computation.

It should be noted that computation of input data in this manner reduced the data read operation from 102 values, including the coefficients a and b, to 5 values—a major reduction. Some saving in computer reading time was gained, which was beneficial, but more important perhaps was the reduction in the key punching load in data preparation.

The principle elements of flowchart construction have been introduced at this point. Greatly increased logical complexity can be achieved by combined usage of these elements.

Substitutions in Several Variables—Nested Loops. Variations in variable values treated so far have always been of one kind, i.e. the subscript i has been varied in order to achieve successive selection of values for substitution in x. Several such series of substitutions on various subscripts can be simultaneously operative and specified for in the flowchart.

As an example, evaluate $y_i = a_j x_i + b_j$; $i = 1(1)n$ and $j = 1(1)m$. This may be read as the evaluation of a simple linear equation with n different values for x_i and m different sets of paired values for the coefficients a and b. Notice that the use of a literal designator for the maximum value for i and j leaves the program free to accept any number of values depending upon the particular computation run requirements.

The flowchart begins with a read of $[a]_j$, $[b]_j$, $[x]_i$, n, and m (Figure 5). Our immediate objective is the computation of a y_i value, but any y_i value is dependent upon a particular selection of coefficients and independent variable x_i. This requires identification of a particular set of these values to be used, which is accomplished through initializations, $j = 1$, $i = 1$.

Having selected the entire set of data for use in computation, the write symbol specifies calculation for y_i. This completes the operation the computed value for y_i along with labelling input data a_j, b_j, and x_i may be written.

An alternative form for the initializations, $j = 1$ and $i = 1$, could be $a_j = a_1$, $b_j = b_1$ and $x_i = x_1$ respectively. The two forms are fully equivalent. The only advantage to the one shown in the flowchart is greater conciseness.

First and Last Sequence Significant. Mental processes associated with flowchart construction may be of some interest. It is suggested that the engineer preparing a flowchart carry in his mind the requirements for program specification in terms of the first and last passage through a computation sequence.

Initialization, computation and write steps just completed were largely determined in recognition of the requirements for the first passage through the computation sequence. Having written the output data, it is now possible to consider termination for the process when all required values have been computed.

This is handled, as before, by a test and two-way branch. First, write a test of i against n to determine whether or not all values of x_i have been evaluated with a constant set of coefficients a_j and b_j. On the first passage through the program i will be equal to 1 and the "less than" branch will be taken followed by modification increasing i to the next value. A return to a new y_i calculation follows via fixed connector 2.

Additional Test for Co-efficients. The program described so far will execute the sequential computation of y_i values with systematic variation of x_i values, i varying from 1 to n. At the conclusion of n such evaluations, the "equals to or greater than" test branch will be followed leading to a second test to determine whether all m values of the a and b co-efficients have been used in computation. This is expressed by testing j against m. For values of j less than m the "less than" branch will be followed and j will be modified by the substitution, $j + 1$ becomes j, and a return to fixed connector 1.

Note that the return through the fixed connector 2 necessarily followed the initialization for i. This obviously was necessary to avoid re-initialization of i, which would have specified the constant use of the first value for x_i, something entirely undesired. Similarly, the return to the early computation following j modification must return to a point subsequent to the j initialization, as shown at the fixed connector 1.

Possible Nested Loops Unlimited. A characteristic pattern for nested loops has now been developed. Note that the early program contains alternate initializations and fixed connector return points for the j and i variable modifications. The test of i against n and j against m, which return the computation, have an inverted order relative to the initialization sequence for j and i. Note also that the re-entry at fixed connector 1 calls for an immediate re-initialization of the x_i variable to x_1.

Upon testing j against m and following the "equal to or greater than" branch, the computation is concluded.

In principle there is no limit to the number of nested loops which may be used to generate large families of data based on systematic variation of parameters.

This discussion has covered the substitution of both arbitrarily specified and systematically varied parameter values, along with the necessary means for specifying input/output operations, branching and looping for repetitive calculation.

Part II will discuss some additional flowchart elements that greatly extend the power of the flowchart as a descriptive device, and the use of the computer in logical operations, the least understood field of computer application. Practical examples of computer application to pipe line engineering will also be given.

FIGURE 1—Snow removal is a problem throughout the course of the Haines-Fairbanks 8-inch products pipe line. Temperatures have been recorded as low as 83°F. below zero at Snag, Yukon Territory of Canada and as high as 92°F. above zero at Fairbanks.

Products Line Operates Year 'Round Despite Alaskan Temperature Extremes

Variations in ambient temperature from 83° F. to 92° F. cause continuous build-up and reduction of pressure due to expansion and contraction of product

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Chief, Alaska Petroleum Distribution System, U. S. Army
and **H. T. Brundage**
PIPE LINE INDUSTRY Staff

TWO YEARS of operation have presented many unusual problems for the Free world's northernmost pipe line. The Haines-Fairbanks pipe line was constructed to transport liquid fuels from the deep water port of Haines in southeastern Alaska to military installations north of the range in the interior of Alaska. (See PIPE LINE INDUSTRY, October and November, 1955). With more than 25 major river crossings, 82 stream crossings, 49 highway crossings, the pipe line extends over the coastal mountain range and through plateaus and valleys of the Yukon and British Columbia Territories, Canada and Alaska.

Along this route temperatures have ranged from a low of —83°F. at Snag, Yukon Territory, to a high of 92°F. at Fairbanks, Alaska; a spread of 175° F. The line is made up of 626 miles of 8-inch line, 432 miles in the Haines-Tok section and 194 miles in the Tok-Fairbanks section. There are three booster stations (Border, Junction and Donjek); two takeoff stations (Fort Greeley and Eilson Air Force Base); and supporting terminal

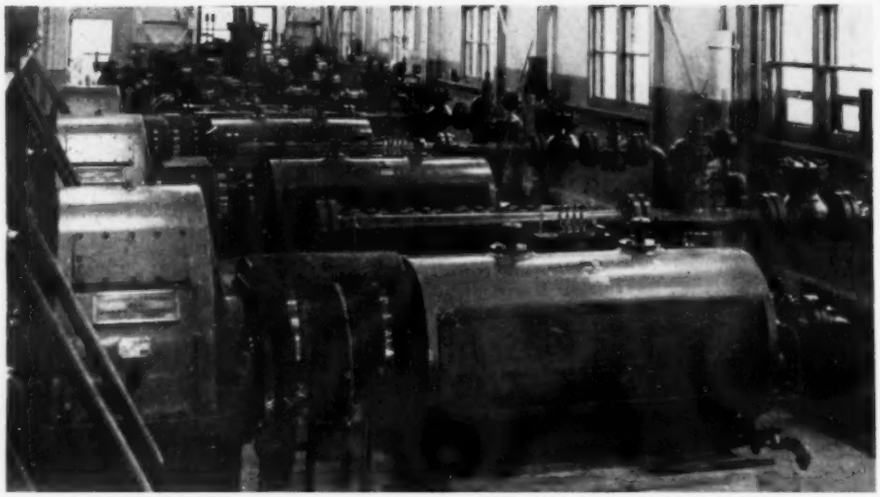


FIGURE 2—Three 5-barrel reciprocating pumps at Tok Terminal main pump building.

bulk storage tanks and related equipment and facilities.

Elevation Changes Effect Pressure Gradient. While the net vertical rise is only 400 feet from Haines (elevation 30 feet) to Fairbanks (elevation 430 feet), a peak elevation of 3,750 feet is reached at mile post 57. Other elevations of 3,300 feet at mile post 90, 3,350 feet at mile posts 162 and 175, 3,050 feet at mile post 252, 1,890 feet at mile post 445 and 1,900 feet at mile post 564 are all limiting factors in the design gradient at normal line throughput.

The line was designed to operate at normal throughput rates with only Haines, Border and Tok stations in operation. Junction and Donjek stations are designed to operate as boosters in an emergency. Construction of two additional booster stations is planned for the future.

Product Dispatching. All dispatching of products through the system is based on movement instructions from the Dispatcher, Products Movement Branch at Fort Richardson, Alaska. The dispatcher's control board, a manually operated panel, presents the pipe line in graphic form. The panel is operated in conjunction with a telephone-teletype communication system.

The control board consists of three parts: paper tape scaled to ⅛ inch per 100 barrels, a pipe line scale profile, and devices for determination of variations of volume due to changes in operating temperatures and pressures.

The scaled paper tape is used to plot accurately the complete displacement of the products in the line by "batches," corrected to reference pressures and temperatures and other operating data such as time of entry into the line and gravity of product. Each batch is indicated by product color code on the tape to provide a visual guide as to the contents of the line. The tape is manually advanced in the direction of product flow at hourly intervals, a distance equal to the net quantity of fluid pumped into the line.

Products currently being transported through the line are:

- Diesel fuel, grade DF-A
- Aircraft turbine and jet engine fuel, Grade JP-4
- Automotive combat gasoline
- Aviation gasoline, Grade 115/145

Line Delivery of Products. Delivery of bulk quantities to designated points is accomplished as follows:

- Tok Terminal—all products are delivered into terminal storage from the Haines-Fairbanks pipe line.
- Big Delta (Fort Greeley) Take-off Station—products are delivered from the Haines-Fairbanks 8-inch pipe line to Big Delta by taking heart cuts from passing batches scheduled for installations further north. Products are taken from 3-inch pipe line by direct take-off.
- Eielson Take-off Station—products are delivered into Eielson Air Force Base tankage from both the 8-inch and 3-inch lines.
- Fairbanks Terminal—products are pumped into terminal storage tanks from both the 8-inch and 3-inch lines for subsequent delivery to Ladd Air Force Base.

Effect of Ambient Temperature Changes. Since most of the line was not buried, the product is subject to extremes in ambient temperature. The

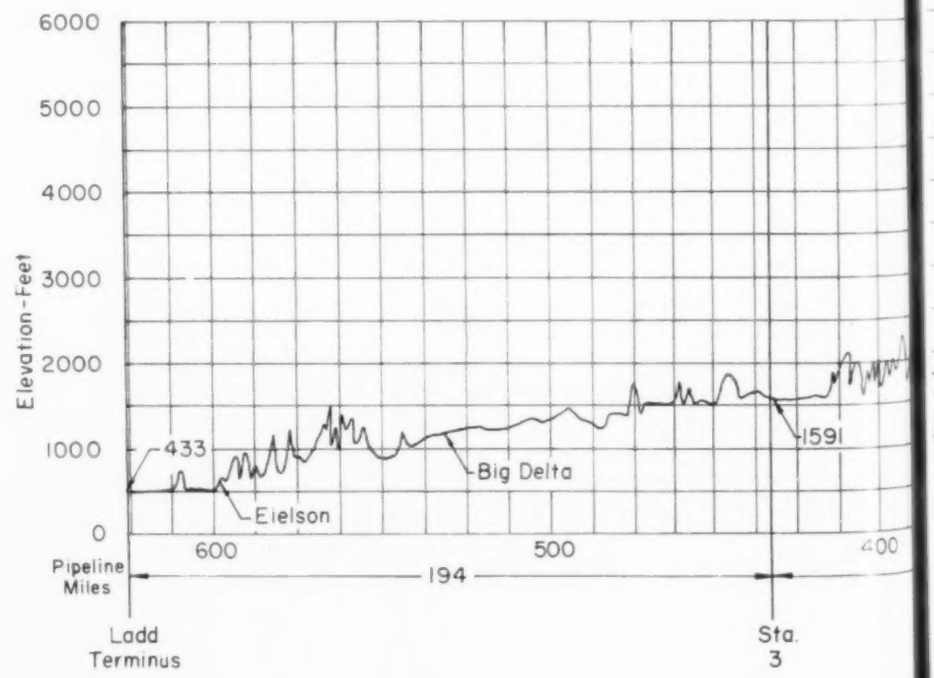


FIGURE 3—Profile of Haines-Fairbanks products line. Although a net vertical rise of only 400 feet occurs, a peak elevation of 3750 feet is reached at mile post 57. The hydraulic gradient is effected by a number of other sharp changes in elevation.

pipe line is packed each time pumping operations are shut down, however, as the products expand and contract with changing temperatures, a continuous build-up and reduction of pressure is experienced. To relieve the pressure in the line during temperature rises, product must be "bled off" into appropriate tankage at Tok terminal. Conversely with the drop in ambient temperatures, products contract or shrink, reducing line pressures. Repressuring is not essential as experience has shown that allowing the line to go slack creates less interfacial mixing than daily repressuring.

Expansion and contraction is so great that during a temperature rise it is possible to receive product at 1,000 barrels per hour at Tok terminal while pumping at a rate of 500 barrels per hour at the Haines terminal; with a sharp temperature decrease, it is possible to pump product into the line at Haines at a rate as high as 500 barrels per hour without receiving product at the Tok terminal. Due to these conditions, it has been necessary to pump at maximum rates to prevent laminar flow in the line. Evaluation of operational experiences and consultants' recommendations point to a requirement for burial of the line to correct these temperature problems. Burial is planned for the fiscal year 1960. This and future MCA programs are estimated to cost $3,075,000.

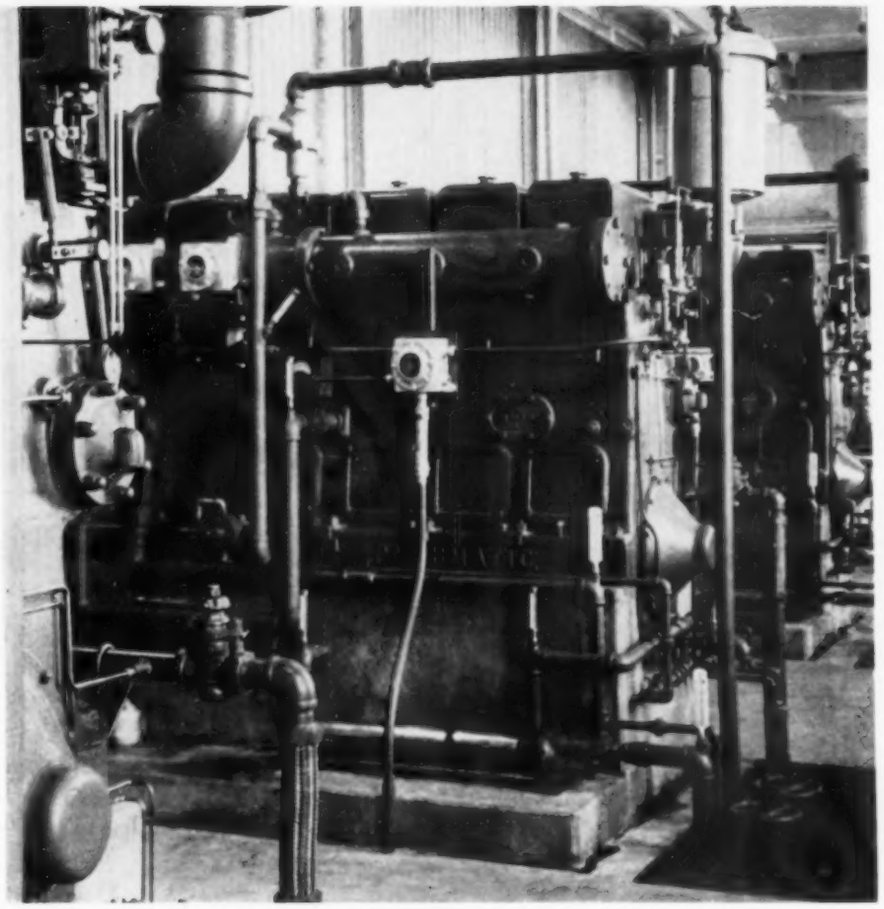
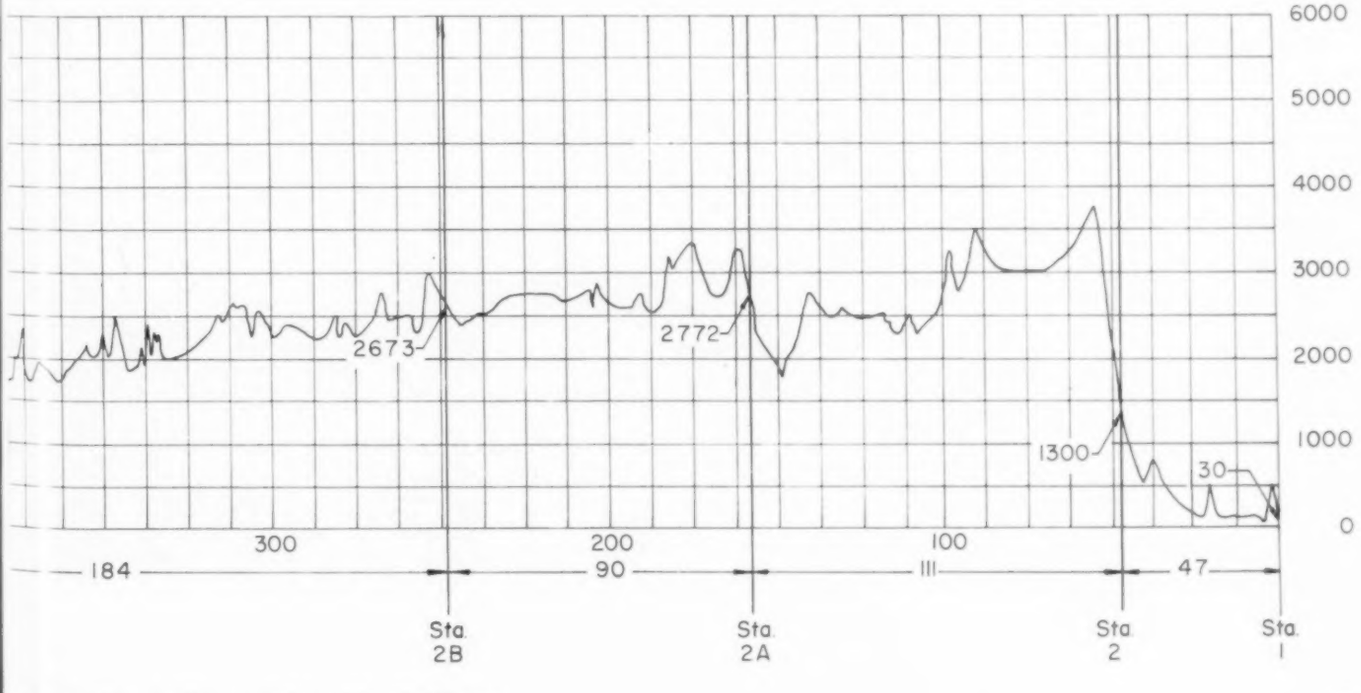


FIGURE 4—View of main line pump building at Tok Terminal. At Tok, products are received through the main 8-inch line and batched through both 8-inch main line and 3-inch Canol line to Fairbanks. The 8-inch pumping equipment includes three main line reciprocating pumps, driven by a 285-hp diesel engine. Maximum capacity on the main line is 1,167 bph with the pumps connected in parallel.

Scraper Traps. The 8-inch line was originally designed to include six scraper traps for cleaning the main line. While the line was under construction, two additional scraper traps were added. During the initial clean-



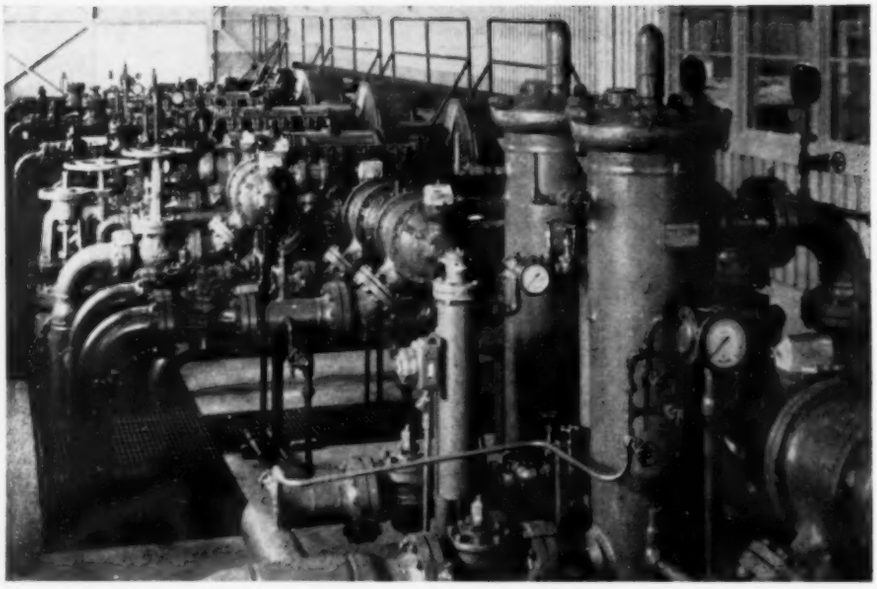


FIGURE 5—View of main line pump building at Tok Terminal. Meters are shown in the foreground with main line pumps in background.

up and first year of operation, it became necessary to install six additional "temporary" scraper traps providing a scraper launching and receiving facility at approximately 50-mile intervals.

Pipe Line Maintenance Patrols. Patrolling of the line is necessary to check condition of line, valves and valve boxes, mileage markers, warning signs, stream crossing structures and vents; and to perform other corrective and preventive maintenance. These men also perform right-of-way maintenance in the control and removal of vegetation.

Responsibilities for specific portions of the line are assigned to four patrols composed of four-man teams as follows:

- **Haines Patrol** from Haines terminal north to Junction Station.
- **Junction Patrol** from pipe line mile post 108 north to Canadian Border.
- **Tok Patrol** from Canadian Border north to Big Delta Take-off.
- **Fairbanks Patrol** three-inch and eight-inch lines from Big Delta Take-off north to Fairbanks terminal.

Personnel assigned to each patrol other than Haines: one petroleum pipe line repairman—foreman, one petroleum pipe line repairman, one welder, acetylene/electric, and one engineer equipment operator.

Personnel assigned to Haines Patrol include: one petroleum pipe line repairman—foreman, one engineer, equipment operator, one petroleum pipe line repairman (furnished by Haines terminal, when required), one welder, acetylene/electric (furnished by Haines terminal, when required).

Additional laborers are drawn, as required, from the Haines and Tok terminals.

Patrols are normally equipped with the following: one truck-tractor, 5-ton; one trailer, semi-low bed; one tractor, full track with side boom; one truck, 2½-ton, 6 x 6, with welding equipment and tools; one stopple (Tok and Haines only); and one back-hoe (Fairbanks only—for buried portion of the line).

Aerial Surveillance of Pipe Line. To facilitate observation of conditions along the line and to particularly detect evidence of leaks and line breaks, both military and civilian aircraft are utilized.

Army aircraft are employed for the surveillance of the pipe line from Northway to Fairbanks terminal, the north portion of the line. The pilot reports any observed leaks, breaks or other conditions warranting immediate attention, advising of the existing condition and location by pipe line mile.

Flights from Haines to Northway are made by civilian aircraft under contract to the government. The pilot reports by radio to Haines, Border, or Junction Station any observed leaks, breaks or other conditions warranting immediate attention, advising of the existing condition and location by pipe line mile.

—The End

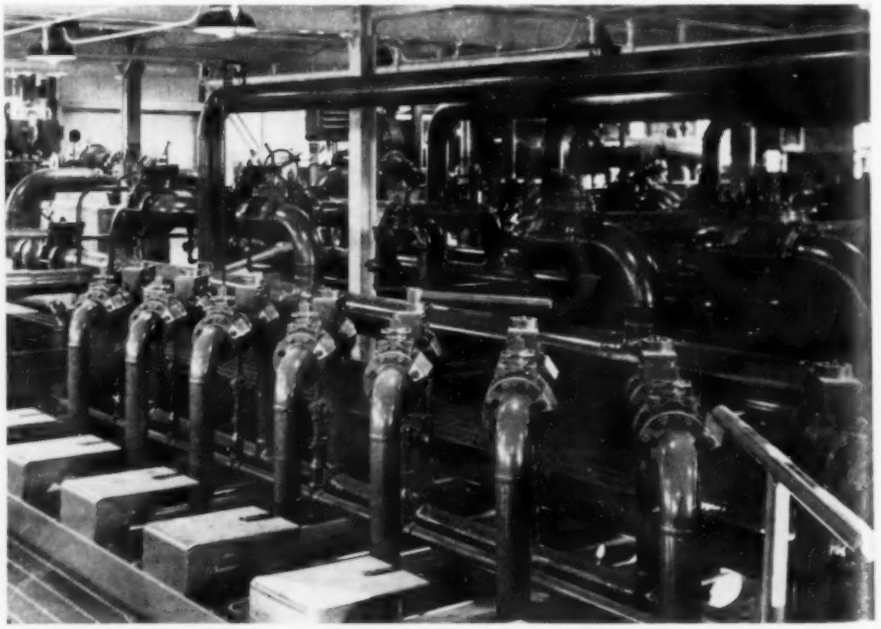


FIGURE 6—Manifold transfer building at Tok Terminal. Products are routed through 3-inch and 8-inch lines to terminal storage tanks and from tankage through water separators to main line pump building. Three transfer pumps are used for product transfer.

PART 2

Today's Trends in the Use of the Tools of Automation

Industry survey indicates wide use of automatic sequence control and unattended station operation

By E. B. Turner
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PART 1 OF THIS SERIES established a scale for comparing the degree of automation. Automated pipe lines were divided into six zones, from complete manual operation to a computer controlled pipe line. Results of a survey of 48 crude and products pipe line companies were analyzed using this scale. The first two sections of the survey were covered in Part 1. This article completes the data gathered for the remaining sections.

AUTOMATIC SEQUENCE CONTROL

The use of automatic sequence control in three main areas—booster pump operation (in conjunction with main units), sequential operation of unit suction and discharge valves, and

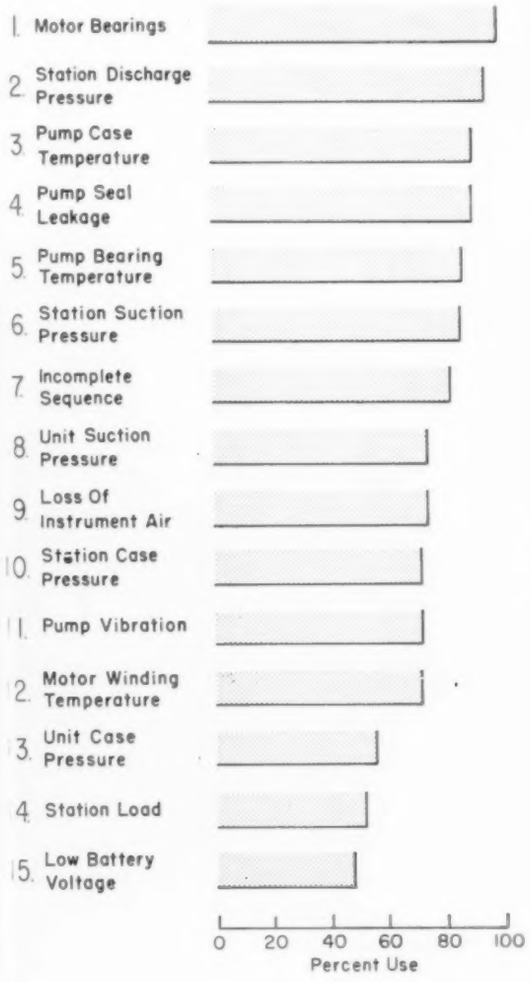
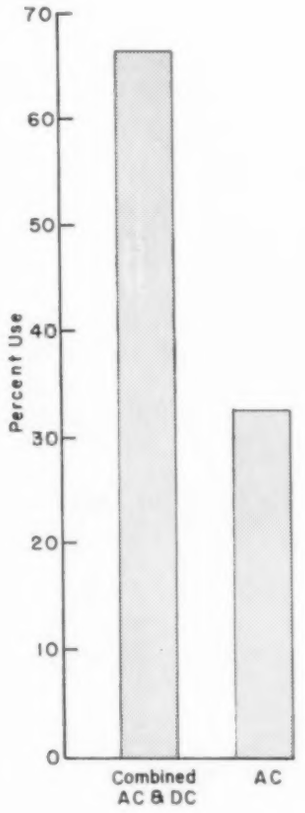
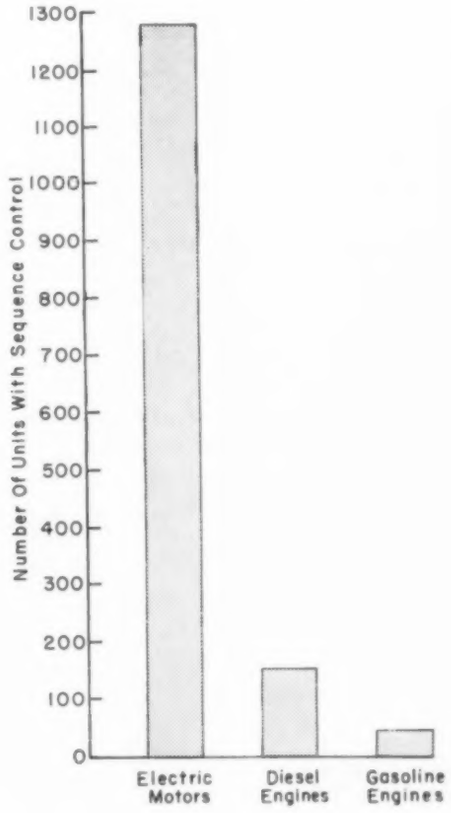


FIGURE 1—(At left) Protective functions for automatic sequence control.

FIGURE 2—(Center) Power sources for sequence control equipment.

FIGURE 3—(Right) Total number of units under automatic sequence control.





sequential operation of main pump units—is covered by this portion of the survey. Results show that sequence control of valves and main units are usually combined. The use of sequence control with booster pumps is less common. Sequence control of main units is employed by approximately 50 percent of the users reporting; booster pumps are used by 30 percent. Of those users who employ main unit automatic control, only 64 percent also utilize sequence control of booster pumps.

Protective Equipment Considered. Various protective functions used in a pipe line station were also covered. The survey listed 15 different protective functions and requested that any functions which had not been listed but which were used should be specified. Results are presented in summary form in Figure 1. The 15 items all have at least 50 percent usage with a majority (12) receiving over 70 percent. Other important protective functions are:

Electrical
- Undervoltage
- Overcurrent
- Current balance
- Channel failure

Mechanical
- Low lube oil pressure
- High lube oil temperature
- High and low flow
- Low gas pressure
- High sump level
- Differential pressure
- Scraper detector

Safety
- Combustible gas detector
- Illegal entry

All of these items received some usage; less than 50 percent in most cases. The exception is high sump level which is either alarmed or causes some subsequent action upon attaining excessive level.

Reliability Depends on Power Supply. Reliability and usefulness of sequence control is largely determined by the power supply. The survey attempted to evaluate this factor. Results are shown in Figure 2. AC powered control systems were used exclusively in 33 percent; the other 67 percent utilized combination AC and DC—which in most cases is AC power for breaker closing and DC for sequence control and breaker tripping.

The total number of units of various types which are under automatic sequence control are shown in Figure 3. Predominance of electric motor drives is undoubtably due to relative ease of adapting this type of drive to sequence operation.

Equipment Needs. Present and future equipment requirements were listed as follows:
- Complete assemblies of protection and sequence control.
- Variable speed a.c. motor (700 to 2,000 hp).
- Reliable gas turbine or free piston engine with an efficiency of 25 percent or better (500 to 1,000 hp).

Unattended Station Operation

This section of the survey is intended to determine:
- Types of unattended stations in use
- Types of supervisory control equipment in use
- Supervisory control safeguards
- Types of telemetering equipment
- Telemeter type readings being transmitted
- Use of data logging

Distribution of Unattended Stations. A total of 186 main line stations are operating unattended. There are 7 main line terminals, 16 tank farms and 80 gathering systems. Fewer terminals are unattended than other type of installation, an indication of the complexity of operations performed at a given point in an operating system.

Types of Supervisory Control. Two basic types of supervisory control reported utilize either:
- Tones or combinations of audio tones, or
- Pulses or coded pulses to form the specific selection codes necessary.

The survey indicates that 19 percent of the basic supervisory control equipment is of the tones or coded tones type with the other 81 percent being of the coded pulse type.

Supervisory Control Safeguards. The possible types of safeguards listed in the questionnaire are as follows:
- Multiple simultaneous frequencies
- Sequential frequencies
- Totalizing of pulses or parity
- Monitoring width of pulse
- Monitoring shape of pulse
- Redundancy or check-back

As shown in Figure 4, the survey indicated the most common method

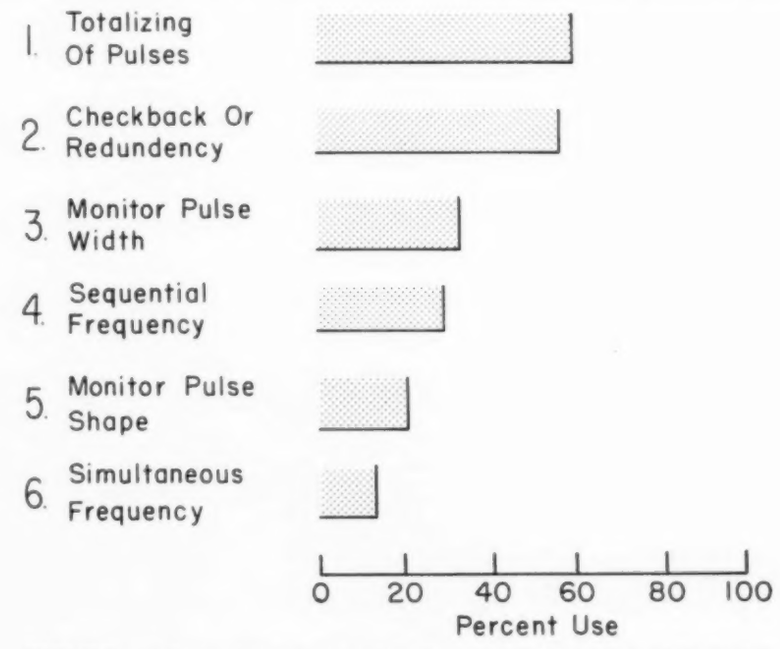


FIGURE 4—Supervisory control safeguards for unattended station operation.

of safeguard is the totalizing number of pulses and redundancy or check-back. The others listed in decreasing usage are monitoring width of pulse, sequential frequencies, monitoring shape of pulse and multiple simultaneous frequencies.

A number of supervisory systems utilize more than one of the listed types of safeguards. It is possible to provide four of the six listed and with either a pulse or a tone system. Three is the average number of safeguards used.

Telemetered Information. Telemetering equipment reported included 453 impulse duration type, 24 frequency type, 35 telegraph type codes, 80 utilizing the weighted binary form of coding and 172 which utilized either a pulse count or cyclic binary code.

Information which is telemetered is shown in Figure 5. The most common readings reported are suction pressure, discharge pressure, flow and case pressure. Other readings are utilized to a much lesser degree. Those readings which are telemetered in some instances but are not listed directly are as follows:

- Temperature of product
- Control valve setting
- Set point setting
- Control position on throttle valve
- Positive displacement meter readings.

It is possible to consider the positive displacement meter reading as a flow reading although this is actually an integration of flow rate. The type of transmission used for this reading is digital in most cases since the accuracy obtainable with an analog type of telemeter (approximately 1 percent) would be of little use when trying to transmit a 6 digit reading accurate to the least significant figure.

Report on Data Logging Inconclusive. For the purpose of this survey, data logging was defined as automatic typing of data at the station where the measurements are made. An attempt was made to obtain an opinion regarding the possibility of replacing local chart recordings with periodic printed information. The consensus was that there was not enough known about the possibilities of this equipment to venture an opinion. Only 15 percent chose to answer this question. Approximately 50 percent thought that logging could replace chart recording with the provision that any deviations of a significant magnitude were recorded.

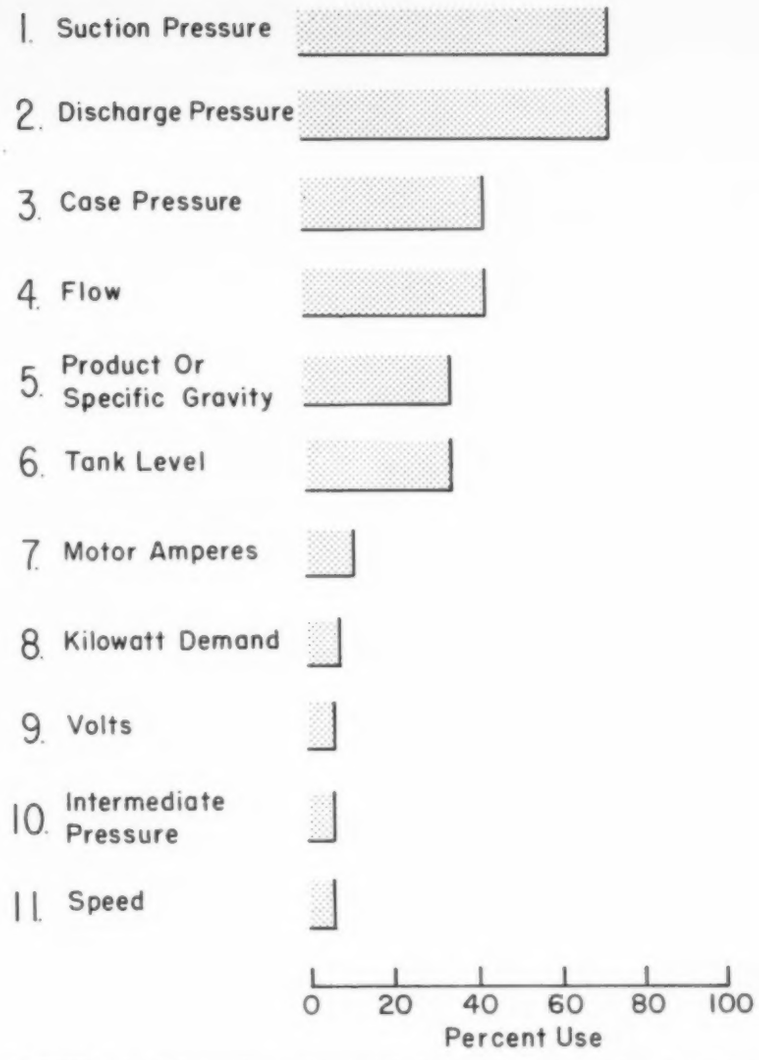


FIGURE 5—Information telemetered for unattended station operation.

The results of the survey with regard to local data logging can be considered to be inconclusive and further investigations would probably be desirable.

Equipment Needs. Some of the equipment required in this category is:

- Solid state analog to digital converter
- Inexpensive deviation detector
- Inexpensive rate of change detector

Operation of Multiple Remote Stations from One Master Control Location

This section of the survey was included to determine the present use of a central headquarters for the control and dispatching of multiple stations. It was not intended to restrict answers to those locations where all of a pipe line's operational information were gathered, but to determine any grouping of operating functions. This information supplements the information pertaining to unattended stations.

Two major divisions were made:

- Supervisory control and telemetering
- Data logging

A total of 114 remotely controlled stations on a total of 22 systems was

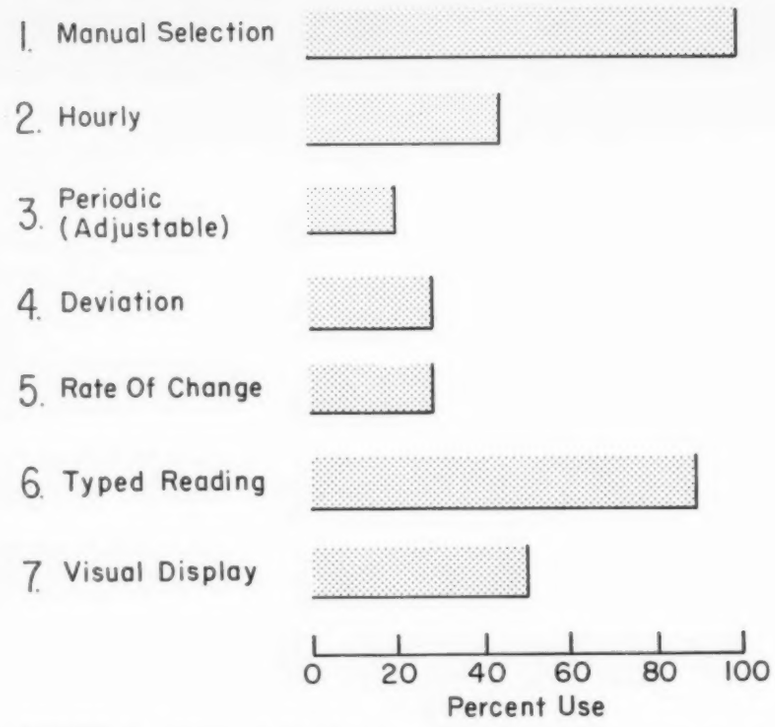


FIGURE 6—Features of data logging systems for multiple remote station operation.

reported—an average of 5.2 stations per system. Distribution of multiple stations indicated 3 or 4 stations per system is considered a maximum. Availability of the time shared channel facilities to perform required operations and receive information being forwarded by the remote stations could be the limiting factor.

Telemetered Information Varies. There are 23 common telemeter systems with an average of 12.4 readings per system for a total of 284 readings. Several users operating common supervisory control systems do not utilize common telemeter systems. On the other hand, some with common telemeter systems do not utilize common supervisory control systems. Referring to the common telemeter data, the minimum number of readings transmitted appears to be three per station and these are the three most commonly used readings of Figure 5. The average number of telemeter readings per system and its relation to the average number of stations per supervisory system do not appear to have any direct correlation. This is probably a result of the disagreement in practice regarding common telemeter systems and independent supervisory systems. Of those companies utilizing independent telemetering equipment, 269 continuous telemetering systems were reported, whereas, those which are available on a selected basis total 35. Twenty percent of all users have both grouped and independent supervisory systems, as well as grouped and independent telemeter systems. From the results of the survey, it was impossible to determine any trend in this area.

Data Logging Systems. Fifteen data logging systems are in operation by users participating in this survey. Many types were reported, a number of them utilizing telegraph coding for transmission and logging of data. An average of 13.8 readings per system was reported with a maximum of 62 and minimum of 9.

Readings are obtained on demand in all cases. In 45 percent of the systems the readings are obtained on an automatic periodic basis, generally once per hour. An adjustable (15 minute increments) periodic reading is provided in 20 percent of the logging systems. Features of the various data logging systems are summarized in Figure 6. Deviation and excessive rate of change readings are provided in only 25 percent of the systems. The readings are typed out in 90 percent of the systems; in no system is the information put on magnetic tape. In only 50 percent of the systems is a visual display used in addition to the typed out record. In one instance, information used in conjunction with the data logging system is also chart recorded at the point of data logging.

Data Aid Dispatching and Operation. Data is used as a dispatching aid and for operational information; in only one instance for accounting purposes. At the present time, no telemetered data or supervisory control information is fed directly to a computer. All the possible uses of the data have not been determined. It is probable in view of the use for dispatching and operational purposes, that until some use is made of computers, no use of the data transmitted will be made for computer input.

Equipment Needs. Equipment requirements in this area are essentially the same as listed under unattended station operation.

Computer Usage

This section of the survey is intended to determine the present and future usage of computers in three areas.

A. Dispatching Aid: Uses suggested were solving dispatching problems and as a result, the use of the computer to formulate dispatching schedules.

B. Performing Pipe Line Operations: In this category the survey suggested the possibility of using the computer to store pipe line hydraulic data, pipe line operational data, to keep track of various pipe line operational information and as a result to formulate, implement and control a dispatching schedule. As an adjunct to this operational control, the computer could also be considered as the source of records concerning inventories and operational data.

C. Accounting and Billing: This category is divided into (1) inventories with regard to the flow data, tank storage data and corrections necessary to provide accurate inventories; (2) shipper billing with regard to recording of shipment receipts and conditions, transfer times, volumes and summations over extended periods.

Computer Usage Widespread. Of the replies received, 67 percent had

Continued on Page 39.

ENGINE RING

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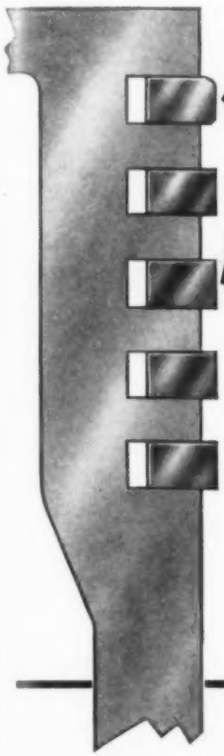

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THE SOLUTION MAY BE IN THE THIRD GROOVE—NOT THE FIRST!

If you've had trouble with your top piston rings (excessive groove wear, groove damage, ring breakage, etc.) you won't need to be convinced that the top ring carries from 50 to 80% of the sealing load. Installing top rings of special, expensive materials is often not the answer. They may be shock-resistant but generally lack adequate wearing qualities. One likely solution is installation of a Cooktite sealing ring in the THIRD groove to relieve the load carried by the first ring. In an engine with a compression pressure of 500 psi and a firing pressure of 1000 psi, a Cooktite ring in the third groove will reduce the pressure differential on the top ring from a trouble-causing 750 psi to an easily-handled 500 psi. Ask a C. Lee Cook representative to explain in detail.

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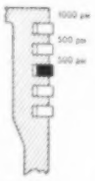
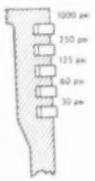


WITH COOKTITE SEALING RING IN THIRD GROOVE

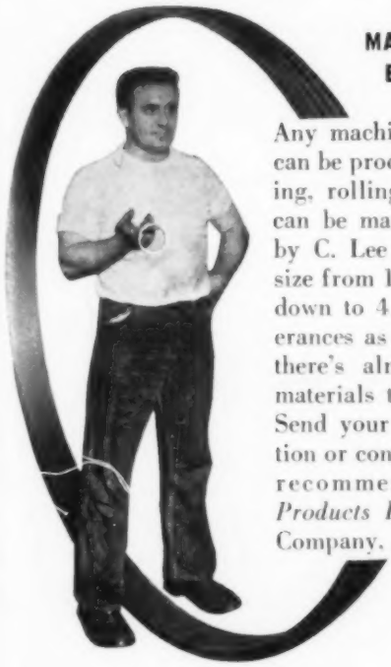
500 psi



WITHOUT COOKTITE RING IN THIRD GROOVE

750 psi

MACHINED ROUND SHAPES FROM ANY MATERIAL



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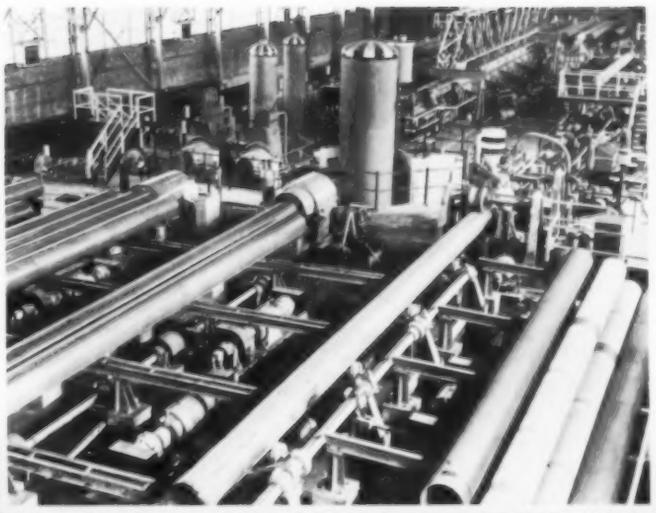

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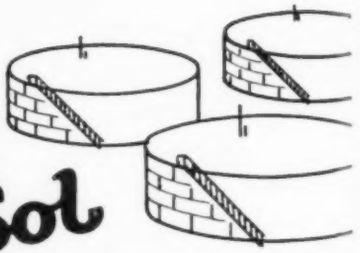

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oday's Trends in the Use of the Tools of Automation

(Cont'd from Page 34)

ther present or future use for computers. Thirty-three percent either had no use for computers or were not willing to express an opinion.

Figure 7 is is a summation of the survey results. For each of the 16 possible computer uses, the following information is given:

1. **"Use Factor"**: percentage of those expressing the opinion that computers could be used in a given function actually using computers for that function.
2. **"Probability Factor"**: percentage of the total number of companies participating in the questionnaire expressing the opinion that a computer would be used in a given function. This factor assumes that those companies *not* expressing an opinion did not think that the computer would be useful in their particular area.
3. **The type of use** for the computer as it participates in the three major areas covered by this section of the survey.

		USE FACTOR (PERCENT)	PROBABILITY FACTOR (PERCENT)	CATEGORY
1.	BILLING SUMMATIONS	38.5	36 (7)	C
2.	FLOW RATES	30	41.7 (5)	B
3.	TANK STORAGE	29.4	47.3 (3)	C
4.	RECEIPT OF SHIPMENTS	26.7	41.7 (5)	C
5.	FLOW DATA	22.2	25 (9)	C
6.	TRANSFER TIMES, VOLUMES	20	41.7 (5)	C
7.	CORRECTION FACTORS	18.8	44.5 (4)	C
8.	TENDER LOCATIONS	14.3	39 (6)	B
9.	PIPELINE OPERATIONAL DATA	13.3	41.7 (5)	B
10.	TERMINAL INVENTORIES	12.5	44.5 (4)	B
11.	PRESSURE CONTROL SETTINGS	12.2	25 (9)	B
12.	RECORD OF INVENTORIES AND OPERATIONAL DATA	11.8	47.3 (3)	B
13.	SOLVE DISPATCHING PROBLEMS	11.1	50 (2)	A
14.	FORMULATE DISPATCHING SCHEDULE	10	55.5 (1)	A
15.	STORE P. L. HYDRAULIC DATA	7.15	39 (6)	B
16.	IMPLEMENT CONTROL AND DISPATCHING	5.75	47.3 (3)	B

NOTES-
1- NUMBERS IN ( ) INDICATE PROBABILITY RANK
2- CATEGORIES:
A- DISPATCHING
B- OPERATING
C- ACCOUNTING

FIGURE 7—Present and future application of computers in pipe line industry.

Accounting and Billing Most Widely Used. The "Use Factor" has a maximum figure of 38.5 percent and a minimum of 5.75 percent, in contrast to a maximum "Probability Factor" of 55.5 percent and a minimum of 25 percent. In comparing the "Use Factor" figures with the "Probability Factor", the two are quite far apart in most cases. For example, the maximum "Use Factor" is on a function which is considered by the replies to be seventh in the line of probability for usage. On the other hand, the maximum "Probability Factor" item is on a functional use which is fourteenth in the use factor. Generally speaking, the accounting and billing areas are in greatest use, followed by the operational and dispatching areas.

Some other uses not covered by Figure 7 are:

- Economic studies
- Delivery estimates—future and actual
- Personnel reports
- Engineering design problems
- Head loss calculations
- Processing gathering run tickets
- Lease tank table storage

—The End

Correct procedures for . . .

Field Sampling Gas

Use of proper field techniques improves quality of samples

By Norman E. Watson
Panhandle Eastern Pipe Line Co.
Liberal, Kan.

SINCE NO analysis has greater accuracy than that of the sample from which it is made, results of analytical tests on natural gas depend on the care with which the sample is obtained and transported. Tests run on poorly gathered samples are worthless, but knowing the purpose for which samples are to be used and the conditions under which they must be secured will tend to eliminate errors.

Since conditions vary widely, special precautions are necessary when obtaining samples since some natural gases contain condensable constituents; others, appreciable quantities of constituents which may react with ordinary materials such as iron, steel, copper, brass and rubber. These require particular sampling techniques.

This hookup is recommended when sampling pure hydrocarbon gases in pressure containers and where condensation is not a problem . . .

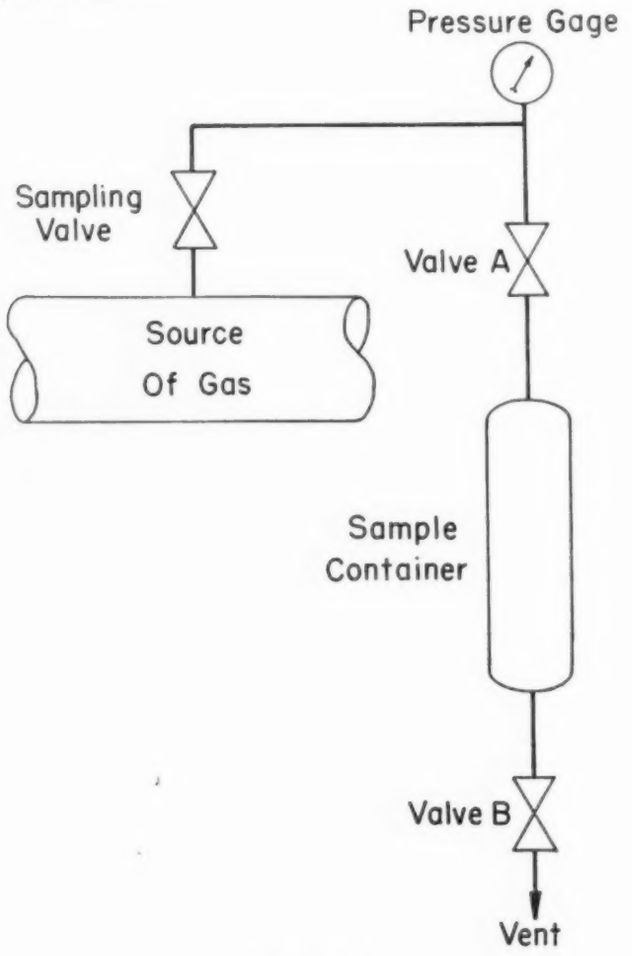


FIGURE 1

General rules. Contamination of the sample means inaccurate test results; only clean, dry containers should be used. Pressure containers may be flushed with steam, with any fusible type safety devices removed beforehand.

Containers for samples to be transported by common carrier must comply with Interstate Commerce Commission regulations regarding labeling, construction and testing.

Pressure containers should be tested regularly. They also should be rated well above the source pressure.

No sample should be taken unless the well production or pipe line flow is fairly steady and normal. A well should have been producing long enough to assure a representative sample. Care should be taken that no dead space exists between the sample tap and the gas stream.

Samples should be stored so that condensation does not occur; and when suspected, the container should be heated to vaporize condensate before using.

Minimize fire hazards in all sampling operations. All containers should be tested for leaks after obtaining samples, and stored where leaks will not create a potential fire hazard.

Tag each sample immediately, noting the sample point, date and time, pressure and temperature of the source, rate of flow, pressure of sample, information desired from the analysis and the name of the person taking the sample.

Sampling gas by displacement. Completely fill a clean glass or metal container of ample size with clean fresh water (the water should be at the same temperature as the source being sampled), and cork tightly. Invert the container in a tub of water so the opening is below water level, then remove the cork. Insert the end of the sampling tube into the open end of the bottle and allow gas to displace the water. Stopper tightly

rubber stoppers should not be used), remove the container from the tub, wire or clamp stopper securely in place and seal with hot paraffin or sealing wax. Properly identify the sample in the container.

Gases containing water soluble constituents (hydrogen sulfide, carbon dioxide, etc.) cannot be collected by water displacement without altering the sample. Such samples should be collected in a clean, dry, glass bottle by extending the free end of the sampling tube to the bottom of the bottle and letting the gas flow briskly for 15 minutes or longer. (If the gas is lighter than air, turn the bottle upside down.) After the gas has displaced the air, the bottle should be stoppered and sealed.

Sampling pure hydrocarbon gases. Where condensation is not a problem, a container is connected to the source as shown in Figure 1. (Container should have a pressure rating greater that that of the source.) Open the sampling valve, inlet valve *A* and outlet valve *B*, and allow the container to purge for at least five minutes to displace any air or foreign gas. Close valve *B*. When the pressure gage shows desired pressure, close valve *A*. Close the remaining valves, disconnect the container, attach the proper tag, and check the container for leaks.

Here is low pressure sampling hookup which is used when dealing with condensing or wet gases . . .

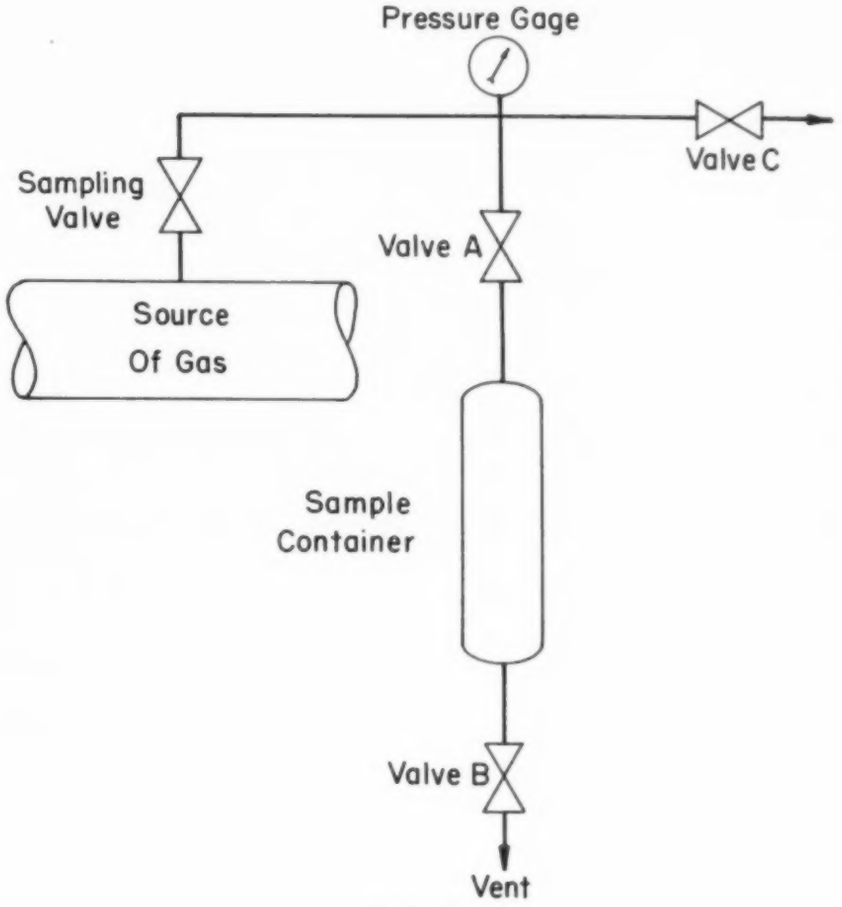


FIGURE 2

Sampling condensing or wet gases. Because wet gases have a higher percentage of hexanes and heavier constituents, every precaution must be taken to prevent partial condensation of the sample. Should condensation occur between the source and the container, the sample would be deficient in heavier constituents. If condensation occurred in the container, the sample would show an excess of heavier constituents. In either case, the sample would not reflect the source accurately.

The temperatures of sample line and container should be as high or higher than that of the source. Again, the container should be rated at a pressure greater than that of the source. The container is connected as in Figure 1. Open wide the sampling valve and container valve *A* and control purging by valve *B*, maintaining the same pressure on the container as is present at the source. Condensation through expansion cooling will occur at the vent and not affect the sample.

Do not take samples at pressures lower than those of the source unless tests of both low pressure and actual pressure samples have proved to be the same.

Figure 2 shows a low pressure, sampling hookup which allows use of containers with low pressure ratings. Connect the container and open the sampling valve and valve *C*. Adjust valve *C* so the pressure gage registers pressure that is no greater than the working pressure of the container. Be sure the temperature between the sampling valve and valve *C* does not drop low enough to cause condensation.

Open valve *A* wide and control the purging with valve *B*, maintaining approximately the same pressure as that between the sampling valve and valve *C*. After purging for at least five minutes, close valve *B*. When the gage shows the desired pressure, close valve *A* and the sampling valve. Disconnect sampling equipment and tag the sample container.

About the Author

Norman E. Watson received a B.S. degree in electrical engineering in 1934 at Rose Polytechnic Institute, Terre Haute, Ind. For a brief period, he worked for the Fluor Construction Company as electrician's helper. Later, he joined Panhandle Eastern Pipe Line Company and has been with them for more than 20 years in various capacities, including compressor station operator and in the gas and water laboratory. For the past five years, he has worked as assistant superintendent of gas measurement in the company's Region 1. This position involves all phases of gas measurement and some phases of gas well testing.

Before transferring crude line to gas service, all residual deposits were removed. A solvent detergent solution was run through the line in conjunction with wire brush scrapers. Lead plug was tagged with radioactive bomb to allow a check on progress of the batch.

Canadian Crude Line Cleaned for Gas Service

Cobalt 60 source used to check progress of cleaning solution. Speed maintained at 1 mile per hour

By R. E. Tschupp
Petroleum Service Division
Oakite Products, Inc.

BEFORE PEMBINA PIPELINES could transfer a loop of their crude pipe line to Northwest Utilities, Ltd., for use in the transmission of natural gas, it was necessary to remove all residual oil and wax from the pipe wall. Successful cleaning of the 32.5 miles of 16-inch welded pipe line between Edmonton and Calmar showed the following results:

- Pigging alone would not provide a sufficiently clean surface.
- All soil could be removed with a combination of scraping and detergent cleaning.
- Speed of cleaning solution was gaged successfully using a radioactive source for tagging batch.

Detergent Removes Deposits. During the month preceding its sale, the line was pigged five times to remove the deposits of crude oil and wax adhering to the interior of the pipe. However, this pigging alone did not give the necessary degree of cleanliness for the change over.

To thoroughly clean the interior surface of the pipe of all residual deposits, a combination of scrapers and a solvent detergent solution was used. The solution was made up of 1 part solvent detergent to 10 parts kerosine.

Radioactive Source Tags Plug. Two pipe line scrapers were introduced into the line. The first had been loaded with a Cobalt 60 bomb, which was to serve as a flow indicator. Scintillators were used to follow the plug along the line. This was done to regulate the speed of the batch of cleaning solution. To provide ten minutes contact of the detergent with the pipe wall, the speed was held to 1 mile per hour.

Using a 42 barrel-per-hour gasoline-driven pump, 220 barrels of so

Two pipe line scrapers (right), the first loaded with a Cobalt 60 bomb, preceded the detergent solution through the Pembina pipe line. Radiation from the bomb enabled operators to chart cleaning progress and speed of solution flow.

ution were introduced into the line nd followed by two more pigs. All crapers were equipped with suction-up type seals to prevent leakage of solution.

Gas Pressure Propels Plugs. Crude oil was introduced into the line ahead of the first plugs to build up a pressure head. Natural gas, at 220 psi was pumped into the line forcing the pigs and solution ahead of it.

Scintillator operators checked the radiation from the Cobalt 60 bomb at two-mile intervals and reported by radio to the gas valve controller at Edmonton. It was determined that a

The Cobalt 60 bomb was attached to the first plug. Scintillator operators checked progress every two miles and reported by radio to the valve operator at Edmonton. Solution flow was maintained at about 1 mile per hour.

speed of somewhat more than 1 mile per hour could be maintained with about 100 pounds of gas pressure.

Scrapers Arrive Clean. When the Scintillators reported that the pigs had reached the Calmar end of the loop, the cleaning solution was cut over into the main crude line for return to the refinery. The pigs were removed and examined. They were free of soil, indicating the cleaning operation had been successful; not only removing the crude deposits, but dissolving the wax as well.

A month later the line was cut and valves installed at points 4.7 and 9.2 miles from the Edmonton end of the line. The pipe was inspected thoroughly at these points and found completely free of deposits.

Cleaning solution was mixed in a tank truck (right), then pumped into the line with a 40-bph pump. A total of 220 barrels of solution was used to clean the 32.5 mile length of pipe line. —The End

You CAN Write Better Letters

Of course business letters aren't supposed to read like best-selling novels, but here are six rules which will make your letters sparkle

- **Plan your letter in advance.**
- **Stick to the purpose of your letter.**
- **Write conversationally.**
- **Avoid large obscure words.**
- **Eliminate those "horse and buggy" phrases.**
- **Make it attractive.**

HIGH COLLARS, handlebar mustaches, button shoes and the derby were quite the style once but have long since faded from the American scene.

There are, however, a few reminders of that Gay Nineties period, and one of them is the businesss letter, which in many cases is still struggling along in typical turn-of-the-century style.

Although times and styles have changed, many are still writing letters using words and phrases of 1890 vintage.

You've undoubtedly seen plenty of examples of these "dead language" letters. Are these expressions familiar?

"Please be advised" . . . "In reply to your letter of the 12th" . . . "Yours of the 15th inst. received" . . . "Replying to yours of . . ."

This is only a sampling of the many bewhiskered phrases that make many modern day business letters dull and lifeless.

A business letter isn't expected to read like a page from a best-selling novel. No one expects it to. Its purpose is either to provide information or request information. A business letter should be short and concise and should get across an idea in the simplest, easiest-to-read and most understandable style. And anybody who can talk can write a business letter. After all, a letter is nothing more than a conversation on paper, a substitute for personal contact.

The rules are simple. Follow them and you can become a successful letter writer.

1. Plan your letter in advance. You wouldn't think of giving a speech without planning what you were going to say to your audience. Why write a business letter without advance planning? Two or three minutes spent in marshalling your thoughts will simpify your job and will pay off in the reader's acceptance of what your letter says.

2. Stick to the purpose of your letter. Know what you're going to say and stick to it. Leave the extraneous stuff out. The object of your letter is to provide your reader with information. Skip the chatter that goes beyond that. Remarks about the weather may enliven

PLAN YOUR LETTERS IN ADVANCE

a dull conversation, but they slow down the pace of a letter.

3. Write conversationally. Write as you speak. There's nothing at all wrong with good, ordinary language with one-and two-syllable words and short sentences. There was a time when business letters were staid and conservative to the point of stuffiness. But times and business letters have changed.

Your personality is revealed in the way you converse. Retain that personality in your letters by talking, not writing.

Too, direct your letters to the personality of your reader. If he's the kind of fellow who's deadly serious all the time, your attempts at humor could rub him the wrong way. If he appreciates a quip now and then, he's a natural for a letter in a lighter vein. Don't get carried away, though. Remember, you're still writing a business letter, so moderate your humor. You can be businesslike and friendly without gushing.

Have confidence in what you write. If you don't believe what you're saying, don't write it. An unsure or insincere letter is worse than no letter at all.

Don't "write down" to your reader. A patronizing attitude on your part stands a good chance of irritating him. Strive for the man-to-man approach.

4. Avoid large obscure words. You're probably familiar with the schizophrenic letter writer. He converses in an easy, informative manner, but undergoes a startling change of character when writing a letter. He goes "literary"; his sentences become long and involved, laden with many-syllabled, unfamiliar words that send the reader to the dictionary (or the letter to the wastebasket). "King's English" is okay for kings, not for business letters. Don't try to impress your reader with your vocabulary. That's not your purpose. Large obscure words can be misinterpreted. The reader may not know the meaning; you may not know it yourself. You want your reader to get the point of your letter quickly, without "digging."

5. Eliminate those "horse and buggy" phrases. These trite and meaningless expressions went out before the bustle, but you can still find them in use. The "beg to advises," "instants of the 16th," "acknowledged receipt ofs" and numerous other overworked phrases are dead. Why not bury them? They add nothing to a letter but a stuffy atmosphere and the feeling that you and the company are out of date.

Do any of these look familiar?

acknowledge receipt of—Unnecessary; if you're answering a letter you must have received it.

agreeable to your request—Phooey! That isn't how you'd say it if you were talking.

as the case may be—Sound and fury, signifying nothing.

at the present writing—what's wrong with "now"?

beg to advise—Don't be a beggar. Stop advising, start telling.

due to the fact that—Use "because" or "since" and save four words.

enclosed please find—Use "enclosed is" (he'll find it if you didn't leave it out).

for your information—Save your breath. Anything you say is for his information.

deem it advisable—How often do you "deem" in a conversation?

in the near future—When's that? Tomorrow . . . next month. Be specific.

wish to thank you—Don't wish. Thank him and leave out the preliminaries.

as per your order—Why "as per" anything? "Per" is only appropriate in Latin phrases, as per annum, per capita. Say "three dollars a day," not "per day."

under separate cover—Okay if you're speaking of someone in bed. Be specific: "by express," "by parcel post," etc.

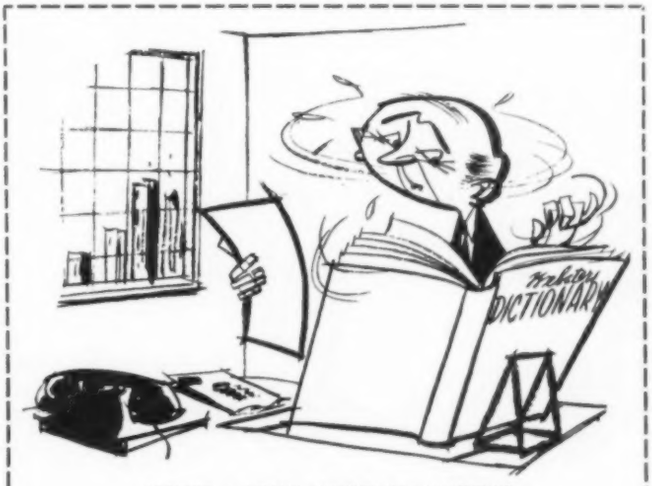
6. Make it attractive. Once your letter is written give it the eye-appeal test. Is it top heavy? Is it badly spaced? Keep it free from smudges, partial erasures and haphazard folds.

The business letter you write reflects on both you and the company. Ask yourself if the letter you have just written is one you would want to receive. If the answer is "no" don't mail it.

There's nothing mysterious about letter writing. It's easy if you follow the rules. Develop good letter writing habits and you'll become an able representative of your company without ever leaving your desk. You too can be a "man of letters."

Reprinted from *Panhandle Lines*

WRITE CONVERSATIONALLY



AVOID LARGE OBSCURE WORDS

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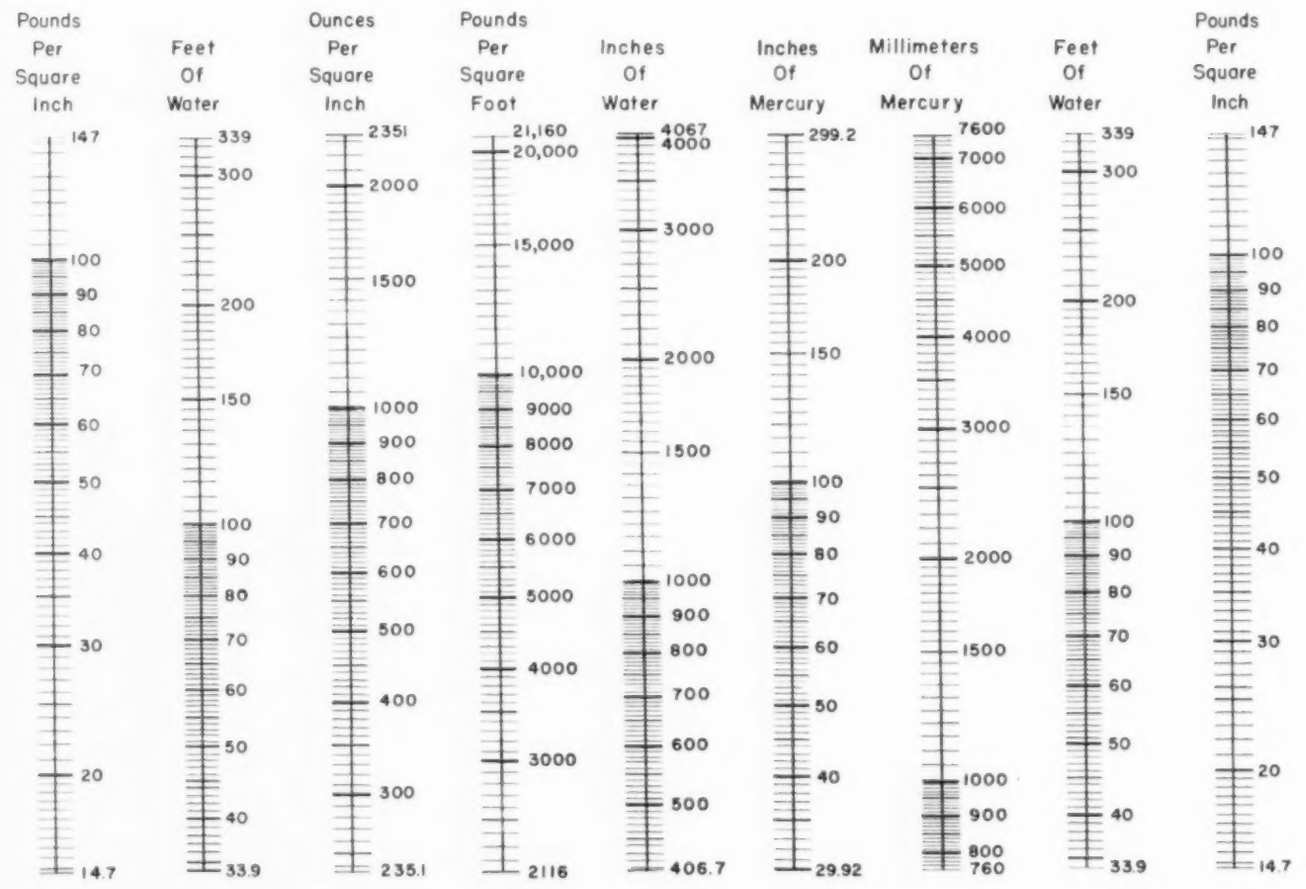
Engineering Design —57—Pressure Conversion Chart

This line chart provides an easy method for converting units of pressure. Draw a line perpendicular to the scale lines through a known value of flow and read the equivalent value on any of the other scales. For values off the scale, known values can be read in multiples of 10 or 100.

Example: Known Value —120 psi is equivalent to:

278 ft. of water
1,920 ounces per sq. in.
1,740 pounds per sq. ft.
3,300 inches of water
242 inches of mercury
6,180 mm of mercury

Submitted by
Marvin H. Green
Philadelphia, Penn.

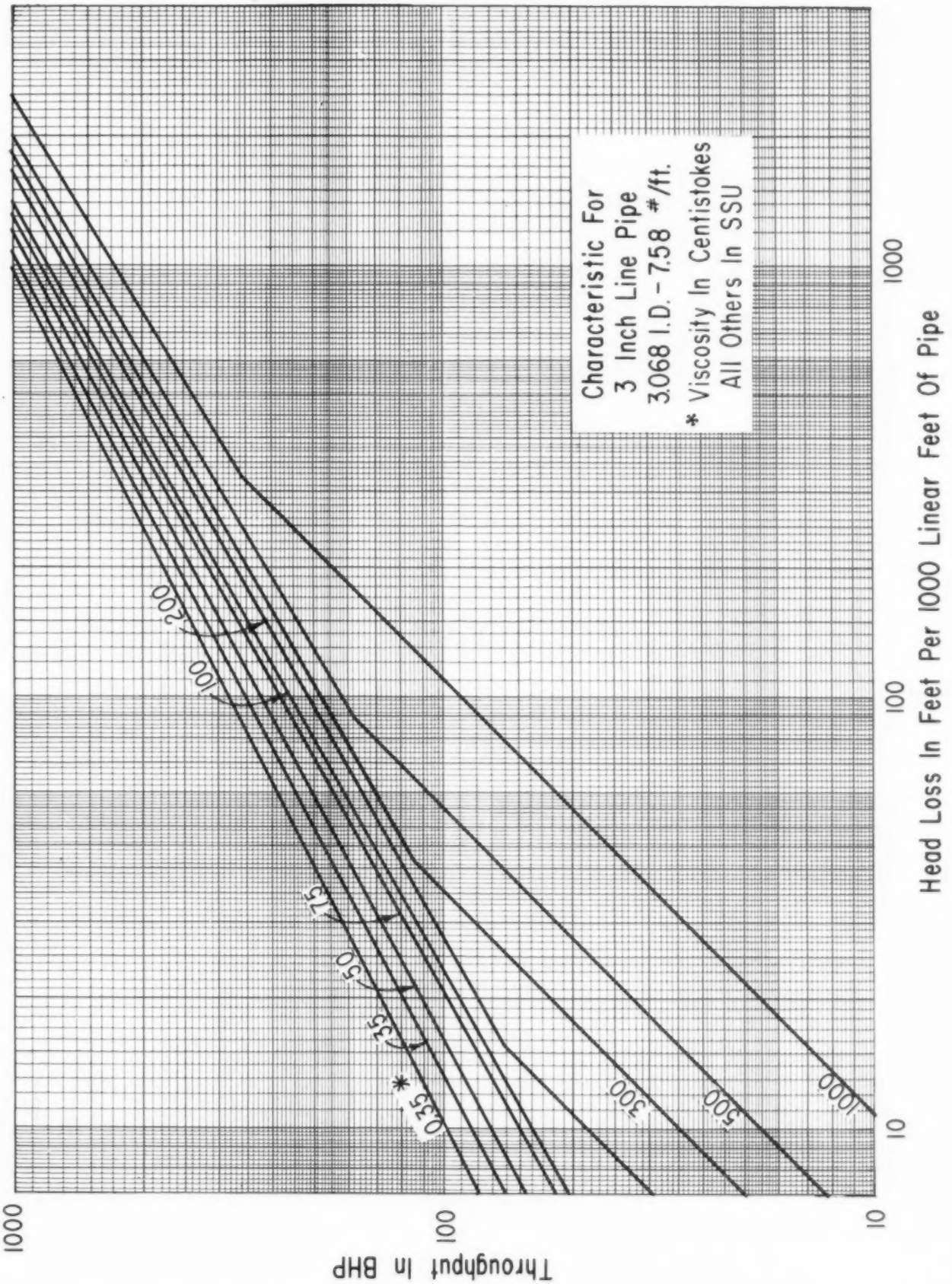


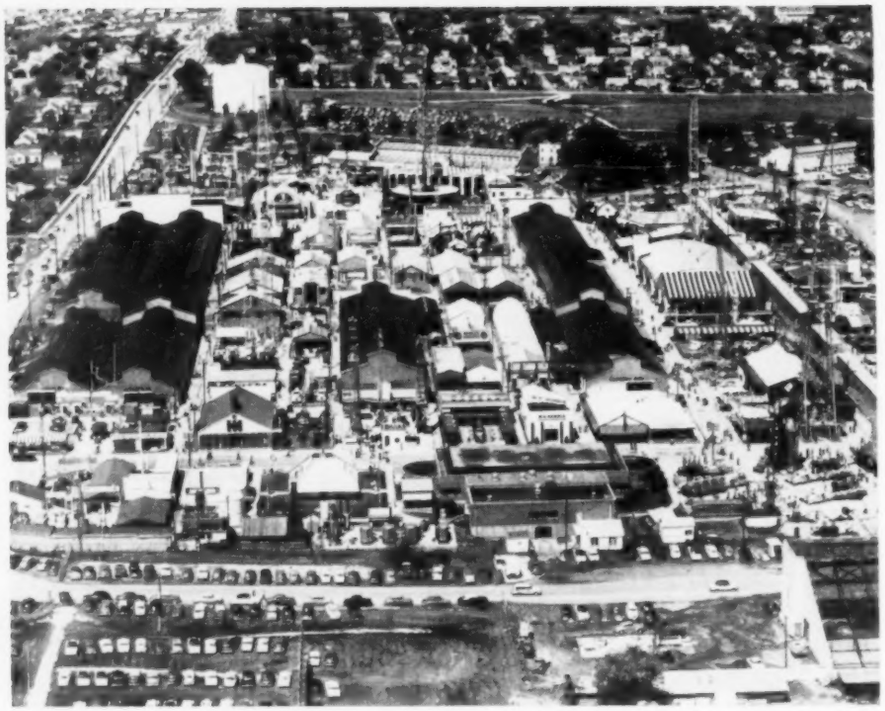
Engineering Design —58—Head Loss Charts for Various Sizes of Pipe

Friction Loss Characteristics for 3-inch pipe were computed by a pipe line company using data of the Hydraulic Institute. Use of these data in laminar and critical zones is adequate for estimates. Friction losses in transition and complete turbulent zones are very accurate.

(Chart 16 in a series of 19—3-inch line pipe)

ENGINEERING DESIGN **58**





1953 INTERNATIONAL PETROLEUM EXPOSITION—This photograph shows some of the 1,484 exhibitors at the 1953 International Petroleum Exposition, at which there were more than 400,000 visitors. At the 1959 exposition, officials expect one-half million visitors and in excess of 1,800 exhibitors, including more than 350 pipe line exhibits.

IPE at Tulsa to Feature Pipe Line Advancements

Exhibits will depict progress of the industry, says Exposition President Warren

EXHIBITS COVERING the numerous improvements and advancements in the pipe line industry will be featured at the forthcoming International Petroleum Exposition in Tulsa, May 14-23, 1959. W. K. Warren, Chairman of Warren Petroleum Corporation and Exposition president, said that visitors to the show will be able to learn more about the pipe line industry in one spot through the Hall of Science exhibits and the expected commercial exhibits than has been possible in at least the last five years.

According to Warren, the Hall of Science transportation exhibit will contain working models on the unattended, automatic remotely-controlled pump stations, advances in communications that have made possible the lowering of unit costs of transporting crude oil and petroleum products and improvements in water transportation techniques.

Centennial Observance. Commemorating the centennial of the oil industry, the 1959 exposition will have more people and equipment in 30 acres than the world has ever seen. Plans are being made to make the opening day ceremonies and parade depict the 100 years of the progress of oil—from Colonel Drake's first effort in 1859 to today's far-advanced methods of exploration, drilling, production and transportation.

Wm. B. Way, general manager of the show, says the grounds will be in the best shape ever for next year's show. "We will probably spend about a million dollars before opening day and expect all facilities to be in excellent condition," he said. Carpenters, painters, electricians and plasterers have been busy for the past three months working on the permanent buildings owned by the Exposition. "Some of the companies already have started to remodel their permanent sites," Way continued, "and one or two of them have started complete reconstruction."

The Exposition and the Fifth World Petroleum Congress have set their dates in conjunction to facilitate foreign attendance at both events. An estimated 6,000 of the world's top ranking petroleum scientists will discuss the present status and the future of science and technology in the oil industry at the World Congress. It will be held in New York, May 30-June 5, 1959. Many of these technical men already have made reservations for the Tulsa show.

Vast Equipment Display. Best estimates available indicate the 1959 show will display about $500 million worth of equipment. Most of this machinery will come to Tulsa from other cities and will present a huge transportation problem. The Tulsa Traffic Club, in conjunction with the IPE transportation committee, has prepared a bulletin for exhibitors which lists all of the transportation facilities available. Railroads, trucking firms and airlines have pooled their service information in one brochure to make the moving task as easy as possible.

Continuing a tradition which was started in 1927 by the late John D. Rockefeller, Sr., the Exposition will recognize the older men in the industry who have contributed so much to its steady growth and progress. A "Pioneer of Pioneers" will be chosen from the industry at large, and six "Grand Old Men" will be picked from divisions within the industry.

Warren sums up the forthcoming show in these words: "All of the new equipment, services, advances and most of the personnel in the industry will be in Tulsa May 14-23 of next year to see what undoubtedly will be the largest single industry show ever held in the world. —The End

IN PIPE LINE CONSTRUCTION

By Donald G. DePugh, Pipe Line Industry Staff

95-Mile Products Line Planned for Puerto Rico

A 95-mile, 8-inch products pipe line is planned to carry products from the Puerto Rico refinery at Penuelas to the San Juan port.

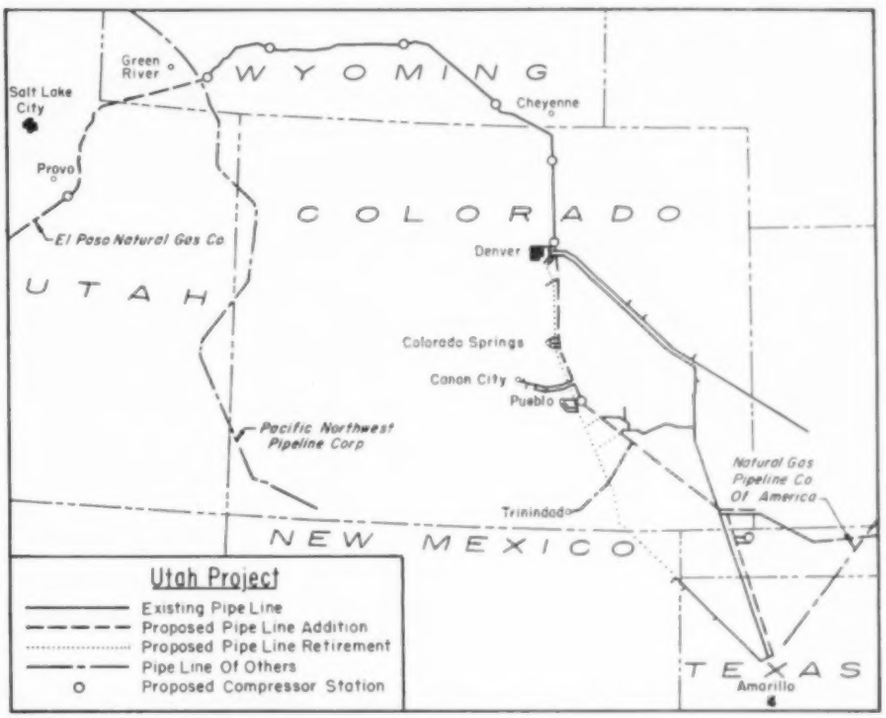
Pipelines of Puerto Rico, Inc., has been formed to build the line by mid-1959. The new line will take products from Commonwealth Oil Refining Company's 55,000-bpd refinery in Penuelas.

The present tanker route from the refinery around the east coast to San Juan is about 150 miles. Pipelines of Puerto Rico has applied to the Public Service Commission of Puerto Rico for permission to construct the line which will carry motor fuels, kerosine and LPG.

Ultimate capacity will be 27,000 bpd with one pump station at Guayanilla, near Penuelas.

Pipe Line Technologists, Inc., has completed engineering studies for the line and construction is expected to get under way shortly.

Plans already are being made to extend the line westward from San Juan to the Ramey Air Force base, a distance of 80 miles. The pipe line company also expects to build lateral lines to the San Juan International Airport and a naval air station in the San Juan suburbs.



Colorado Interstate Gas Company Sends $91 Million Utah Project Before FPC

Colorado Interstate Gas Company has sent its $91 million Utah Project application before the Federal Power Commission. The two-fold expansion program, designed to supply El Paso Natural Gas Company and also make additional deliveries to customers in Rocky Mountain area, calls for construction of nearly 600 miles of 26-, 30- and 34-inch main line extensions and more than 78,000 additional horsepower at nine new compressor stations and four existing ones.

Colorado will lay a 140-mile, 34-inch line from Green River, Wyo., to Provo, Utah, where it will connect with El Paso's line to California. Other plans call for 492 miles of trunk line between the Texas Panhandle near Amarillo, Texas, and Denver. This portion of the project consists of three sections: 109 miles, 26-inch line from the Panhandle area to southeastern Colorado; 136 miles, 34-inch, from there to Pueblo, Colo., and 107 miles, 30-inch from Pueblo to Denver.

Completion of the Utah project facilities will increase Colorado's daily delivery capacity from 690 MMcf to a total of 1.2 billion.

According to its agreement with El Paso, Colorado will sell 200 MMcf of gas daily to El Paso near Green River. Colorado will deliver this gas

Pipe Line Contractors at St. Louis Meeting

Pipe Line Contractors Association held its first fall business meeting in St. Louis in early October. Making plans for upcoming convention in Bal Harbour, Fla. January 12-15 are, left to right, Haily A. Roberts, assistant to secretary; B. E. Barnes, Williams Brothers Company; W. E. Honey, Latex Construction Company; President R. P. Gregory, Houston Contracting Company, Richard A. Gump, executive secretary; and Grahame Somerville, Somerville Construction Company.

and 200 MMcf from Pacific Northwest Pipeline Corporation to El Paso at Provo.

El Paso plans to construct a 400-mile, 34-inch line from near Salt Lake City to the California border to obtain additional gas from the Pacific Northwest to supply customers on the West Coast.

Colorado Interstate is awaiting FPC settlement on its rates and company revenue case before constructing the new facilities for its Rocky Mountain customers. Hopes are high that FPC clearance will come soon in order that Colorado may supply the additional gas for the 1959-60 winter.

With construction of the Amarillo-to-Denver line, Colorado will be able to retire a major portion of its original pipe line between these points and the seven compressor stations on that line.

Cities Service To Build Two Compressor Units

Cities Service Gas Company has been given FPC authorization to construct two compressor units costing $787,000.

The 1,350-horsepower units will be erected in a new station in Haskell County, Kansas, and in Cities Service's existing Ulysses station in Grant County, Kansas.

Arkansas Louisiana Plans 230-Mile Gas Pipe Line

Arkansas Louisiana Gas Company will construct a 230-mile, 16- and 18-inch gas line from near Clarksville to Helena, Ark., on the Mississippi River.

The $15 million project will be carried out by Arkansas Louisiana and its newly formed subsidiary, Arkansas Industrial Pipeline Corporation. The line will be laid in two major segments. Arkansas Louisiana will construct the first 100 miles, consisting of 16-inch pipe and extending from the Aetna gas field in Franklin County to the company's system at Jones Mill, between Malvern and Hot Springs. Cost of this portion of the line is $6 million.

Arkansas Industrial will build the 130-mile, 18-inch section which runs from the system's Perla pipe line junction in Hot Springs County to Helena. This line, estimated to cost $9 million, will enable Arkansas Louisiana to serve the new generating plant of Arkansas Power & Light Company which will be completed in 1961. The Perla-to-Helena line will allow the company to serve industrial, commercial and domestic customers along the route of the new pipe line. The new firm has been formed to deliver gas anywhere in Arkansas Louisiana's territory or contiguous territories serving industrial customers.

Directors of the new pipe line corporation are: Jerry Screeton, planter and banker; John M. Bransford, planter and business man; Ben Hogan, contractor; Haskell Dickinson, Little Rock business executive; Ripley Thompson, merchant and planter; Bert Dickey, banker and merchant; Reb M. Scoggins, long-time employee of A.L.G.; John E. Taylor, A.L.G. pipe line superintendent; Don W. Weir, A.L.G. executive vice president, and W. R. Stephens, president, A.L.G.

Turkey-Iran Agreement Made on 1,000-Mile Line

Turkey and Iran have signed an agreement on a 1,000-mile crude line from Iran to Turkish port on the Mediterranean. The $500 million system will be built to carry 500,000

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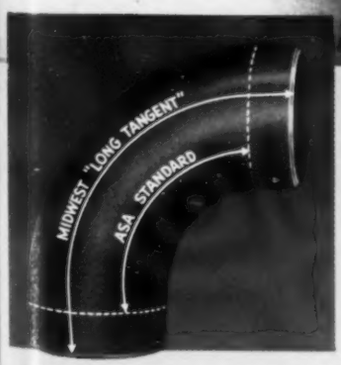

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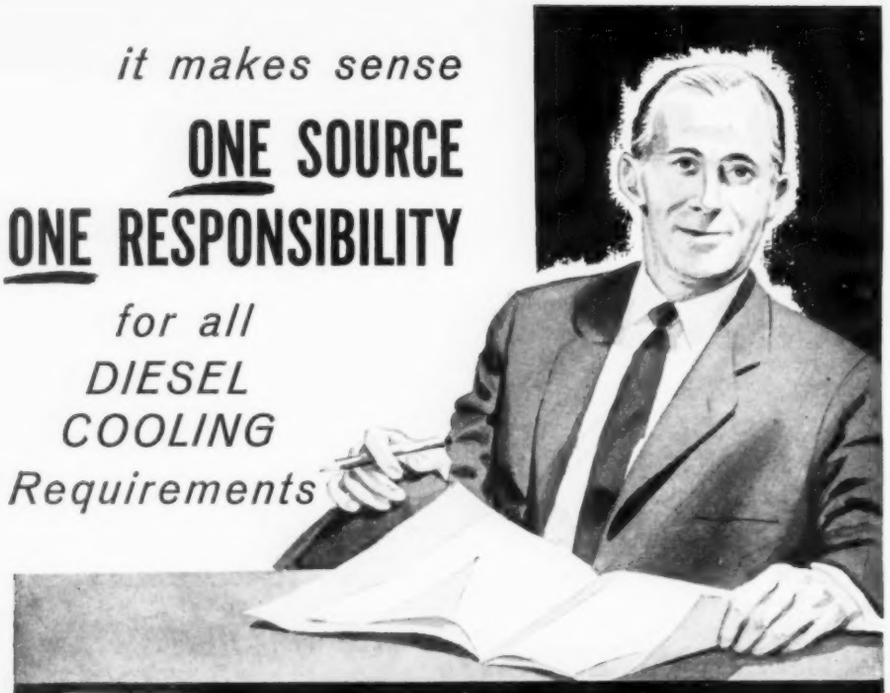

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☐ Cat. No. 3558 — Type 'OH' Unit Oil Coolers

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barrels per day. Branch lines will be laid to the Qum area in Northern Iran and to Abadan. About 550 miles of the line will be across Turkey.

The line will not be constructed anytime soon as the reserves in the Qum area are questionable.

California Companies Plan 200-Mile, 34-Inch Gas Line

Southern California and Southern Counties Gas companies have filed an application with the California Public Utilities Commision seeking permission to build a 200-mile, 34-inch gas line from the Nevada border to a point near Fullerton, Calif.

The line, estimated to cost about $44 million, will originate at Ivanpah Valley, southwest of Las Vegas. It would extend 93 miles southwesterly to Newberry and then proceed 114 miles over the Cajon Pass, through the Ontario-Pomona area and across the Chino Hills to Placentia near Fullerton.

Plans include the construction of a compressor station at Newberry in the Antelope Valley with a total of 16,000 horsepower. Additional horsepower would be added at Newberry and Valley Wells in 1960 and 1961 to bring the total horsepower to 32,000.

Ultimate capacity of the new line would be 800 MMcf of gas daily. Construction is scheduled to start immediately upon certification and is expected to be completed in late 1959.

Texas Gas Authorized To Construct 126 Miles

The FPC recently authorized Texas Gas Transmission Corporation to construct about 126 miles of line, install an additional 9,040 horsepower at existing stations, and construct a 1,800-horsepower compressor station. These facilities, to cost $20 million, will be built in Louisiana, Arkansas, Mississippi, Kentucky, Indiana, Illinois and Tennessee.

The facilities will increase Texas Gas Transmission's system by 133.7 MMcf of gas daily.

Natural Gas Storage Company Granted FPC Authorization

Natural Gas Storage Company has been granted final approval by the FPC to construct facilities for the construction of 2.4 miles of gathering

ines, a 1,330-horsepower compressor plant, 3 observation wells, and 12 injection-withdrawal wells at a cost of $2.5 million.

United Gas Pipe Line Co. Lets Contracts on 55 Miles

United Gas Pipe Line Company has awarded contracts for construction on 55 miles of its 203-mile, 30-inch loop line from New Orleans to Mobile, Ala.

Williams Brothers Company will construct 37 miles of 30-inch from Lyman to Helena, Miss., and Western Pipe Line, Inc., will lay 12 miles, 30-inch in Winn and Jackson Parishes and 8 miles of 16-inch line in St. Charles Parish, Louisiana.

United Gas let contract to O. R. Burden Construction Corporation on 30 miles of 30-inch across Lake Pontchartrain, La., in October.

The total looping project will cost approximately $33.7 million.

Construction to Start On Algeria-to-Tunisia Line

Construction is due to start this month on the 475-mile Algeria-to-Tunisia crude oil pipe line.

The line will extend from the Edjele, Zarzaitine, and Tiguentourine fields of eastern Algeria to the Tunisian port of La Skhirra on the Gulf of Gabes. Trapsa, a new French pipe line company and affiliate of Shell, will build the line with technical assistance from Bechtel International Corporation.

Completion of the line is expected in 1960 with initial operations set for the latter part of that year. Capacity will be 140,000 barrels daily with one pump station. Ultimate capacity is expected to be 260,000 barrels per day with the addition of three pump stations.

British Petroleum Co. Constructing Crude Line

Construction has begun on British Petroleum Company's 60-mile, 18-inch crude line from the Milford Haven, Wales marine terminal to the Llandarcy refinery.

Completion of the line is set for late 1959. Capacity will be 100,000 barrels daily. The pipe will be buried from 2 to 6 feet below ground level.

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Midwestern, TGT, File Companion Applications With FPC

Midwestern Gas Transmission Company has filed a new application with the Federal Power Commission seeking authorization for construction of facilities to supply 360 MMcf of gas daily to the Chicago-Gary area.

In its revised application, Midwestern proposed to construct a $50.8 million, 350-mile, 30-inch line from Portland, Tenn. to Joilet, Ill. Tennessee Gas Transmission Company, Midwestern's parent company and gas supplier, filed a supporting application to build 158 miles of 36-inch line paralleling its existing system in Louisiana and Mississippi to furnish Midwestern its gas at a connection in Portland. Cost would be $61.5 million.

Midwestern originally had filed a plan with the FPC asking permission to build a 1,118 mile system from Portland to Emerson, Manitoba, Canada and import 204 MMcf of gas daily from Trans-Canada Pipe Lines Ltd. This was denied because the FPC ruled that Trans-Canada's proved reserves were not sufficient to allow export.

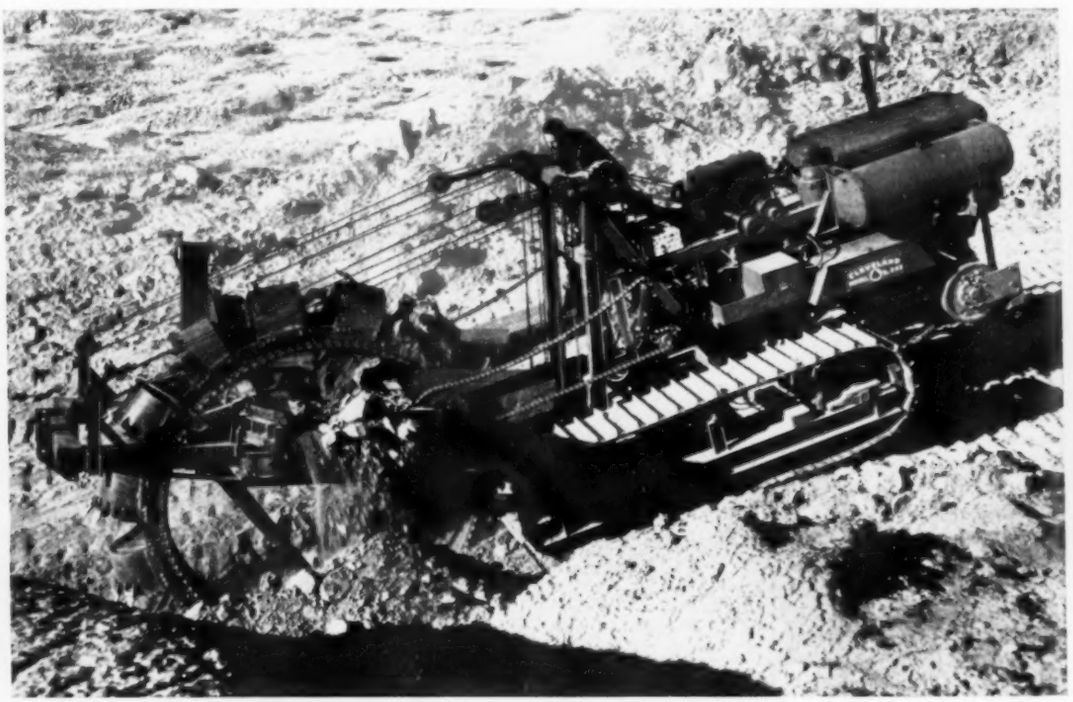
Another application from Midwestern will go before the FPC soon. This project will include construction of a line to Canada and importing Canadian gas to serve communities in Minnesota, Wisconsin and the Michigan peninsula. However, Midwestern's applications and proposed lines will not be interconnected, as was planned in the earlier denied project.

Last month the FPC denied applications submitted by Midwestern, Northern Natural Gas Company and Michigan Wisconsin Pipe Line Company which sought approval to construct facilities allowing them to serve the Midwest area. All companies were requested to submit new applications concerning the three-year old Midwest case.

Northern's proposal called for construction of facilities enabling the company to supply 60.4 MMcf of gas daily to 73 new customers in competitive areas in Minnesota and Wisconsin. Approval was granted Northern for construction of facilities to make available additional service to existing customers in Iowa, South Dakota, Minnesota, and Nebraska.

Michigan Wisconsin's application sought authorization for $32 million of facilities to serve 10 distributors in Wisconsin and Minnesota in direct competition with Midwestern's proposal. Northern's application was rejected due to the company's lack of storage facilities and Michigan Wisconsin was denied approval because of a lack of economical feasibility.

Midwestern's new line would connect with Chicago District Pipe Line Company's Joliet to Chicago line for delivery to Peoples Gas Light and Coke Company, Northern Indiana Public Service Company and Northern Illinois Gas Company. Of the 360 MMcf of gas destined for Chicago, 100 MMcf would go to Peoples Gas, 100 MMcf to Northern Indiana and 60 MMcf would be supplied to Northern Illinois.



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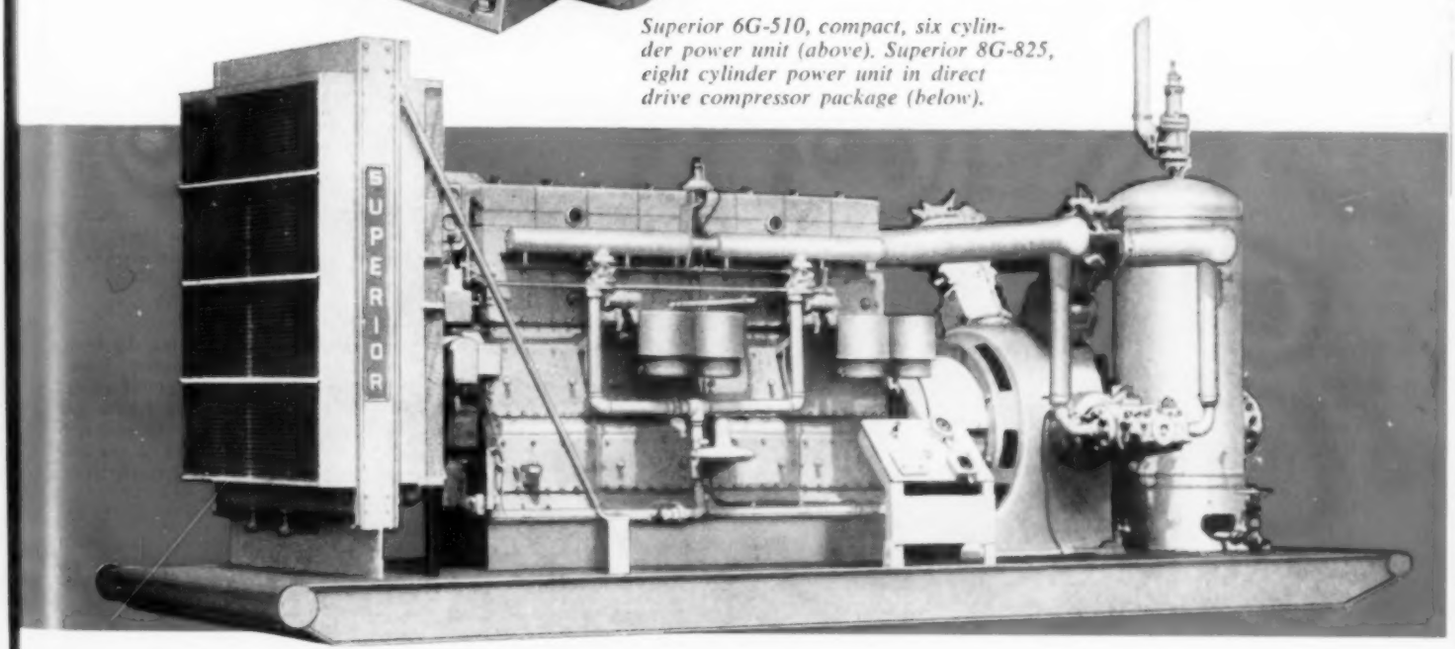
Superior 6G-510, compact, six cylinder power unit (above). Superior 8G-825, eight cylinder power unit in direct drive compressor package (below).



horsepower ratings

model	cylinders	rpm	continuous	intermittent	maximum
6G-510	6	1000	330	370	412
6G-825	6	900	465	525	590
8G-825	8	900	625	705	790

White's conservative ratings indicate actual usable horsepower performance of standard stock engines equipped with radiator. No correction necessary to 1500 ft. elevation and 90° F.

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PROPOSED PIPE LINE CONSTRUCTION

Here in convenient summary form is Pipe Line Industry's listing of company, line size, length, service, location and project status.

U. S.

Arkansas Industrial Pipeline Corp., Shreveport, 130 miles, 18-inch, gas, Perla-to-Helena, Ark., $9 million, planned.

Arkansas Louisiana Gas Co., Shreveport, 100 miles, 16-inch, gas, from near Clarksville-to-Jones Mill, between Malvern and Hot Springs, Ark., $6 million, planned.

American Louisiana Pipe Line Co., Detroit, two 12,000 hp compressor stations in Ohio and Indiana; additional 2,000 hp at existing stations in Mississippi and Tennessee; 3 miles pipe line, meter station in Cameron, La., $7 million, FPC authorization.

Chicago District Pipeline Company, 52 miles, 30-36 inch, gas, from Natural Gas' proposed line at Joliet to Chicago, $13 million, before FPC.

Cities Service Gas Company, Oklahoma City, 106 miles, gas, gathering, in Montgomery, Allen, Franklin, Miami, Johnson, and Wilson counties, Kansas, 3,600 hp to Blackwell station, Kay County, Kansas, FPC authorization.

Coastal States Gas Producing Co., Corpus Christi, Texas, 289 miles, 14 and 18-inch main line and gathering system, McAllen to Falfurrias, Tex., area, and Lopena to La Salle County, $12 million, planned.

Coastal Transmission Corp., Houston, 574 miles, 22-24 inch, gas, from McAllen, Texas to Baton Rouge, La. connection of Houston. Texas Gas and Oil plus 414 miles of laterals, $55 million, contracts let on compressor stations to Gasoline Plant Construction Corp. Contract let on 443 miles, main and laterals, to Oklahoma Contracting Co., and O. R. Burden Construction Corp.

Colorado Interstate Gas Co., Colorado Springs, 140 miles, gas, Green River, Wyo.-to-Provo, Utah; 109 miles, 26-inch, Texas Panhandle to southeastern Colorado; 136 miles, 34-inch, southeastern Colorado-to-Pueblo, Colo.; 107 miles, 30-inch, Pueblo-to-Denver, $91 million, before FPC.

Conn-Mass Pipe Line, Inc., Orange, Conn., 88 miles, 8 inch, products, from Boston to Springfield, Mass., considered.

133 miles, 16-inch, products, from Linden, N. J. to Hartford, Conn., considered.

62.2 miles, 8-inch, products, from New Haven, Conn. to Springfield, Mass., considered.

38 miles, 6-inch, products, from Waltham, Mass. to Fitchburg, Mass., considered.

Consumers Power Co., 45 miles, gas, main line, from Woodbury station to Laingsburg Junction, Mich., planned.

126-miles, 26-inch, gas, main, Michigan-Indiana border to Plymouth, Mich., planned.

El Paso Natural Gas Company, El Paso, 216 miles, 26 to 34-inch main line, 533 miles, 6-20-inch laterals, gas, 86,750 compressor hp; 126 miles, 30-inch main line, 266 miles, laterals, gas, 28,920 compressor hp in new and existing stations in Arizona, New Mexico and Texas, contracts let on 819 miles to R. H. Fulton & Co., McVean & Barlow, Inc., Western Pipe Line, Inc., Eastern Pipeline Contractors, and Engineers Limited Pipeline Co.

400 miles, 34-inch, Salt Lake City, Utah, to California border, planned.

Equitable Gas Company, Pittsburgh, Penn., 11.7 miles of storage pipe line and other facilities, $2,091,430, authorized.

Everglades Pipe Line Company, Miami, Fla., 35 miles, 10-inch, products, Port Everglades to Miami International Airport, $2.5 million, planned.

Gillette Pipeline Co., Cheyenne, Wyo., 103 miles, crude, from Dead Horse Creek field to Casper, Wyo., planned.

Great Northern Railway, St. Paul, 400-600 miles, 12-20 inch, crude, from Williston Basin to St. Paul-Minneapolis and Duluth-Superior areas, considered.

Gulf Interstate Gas Co., Houston, 12.8 miles, 6 and 20 inch, gas, loop line in Louisiana, $730,000, authorized.

Gulf Pacific Pipe Line Company, 1,600 miles, 30-inch, gas, Louisiana to California border, considered.

Gulf Resources, New York, 125 miles, gas, gathering system, from Lopena area in Zapata County to a point in La Salle County, Texas, planned.

Humble Oil & Refining Co., 250 miles, 26 or 30 inch, gas and 116 miles, main gathering system, varying sizes, from southwest Texas to Houston, plus gas processing and cycling plant near Corpus Christi, $75 million, planned.

Iron Ranges Natural Gas Co., 115 miles, gas, from Itasca and St. Louis counties along route of Mesabi range from Grand Rapids to Aurora, Minn., $5 million, before FPC.

Katy and New York Central Railroads, 2500-mile, 10-12 inch, LPG, from Houston, Texas, to New York, considered.

Manufacturers Light and Heat Co., Pittsburgh, Penn., 21-miles, gas facilities in Pennsylvania and West Virginia, $1 million authorized.

34-miles, 20-inch, in Greene, Adams, and York counties, Penn., authorized.

Michigan Gas Storage Co., Jackson, Mich., gas, facilities in central Michigan, $2 million, authorized.

Michigan Wisconsin Pipe Line Co., Detroit, 621 miles, gas, 14,280 additional hp, $32 million, appeal before FPC.

20.5 miles, 24-inch, main line loop in Michigan, before FPC.

Midwestern Gas Transmission Co., Houston, 350 miles, 30-inch, gas, Portland Tenn. to Joliet, Ill., $50.8 million, before FPC.

Mookl Chemical & Gas Corp., Tulsa, and Missouri Transmission Corp., Springfield, Mo., 425 miles, 16-inch, gas, from Oklahoma City area to St. Louis, before FPC.

New York State Natural Gas Co., Pittsburgh, 30 miles, 20-inch, gas, main Silver Springs to East Elma, N. Y. $1.6 million, temporary FPC authorization.

North Carolina Natural Gas Corp., 630 miles, 2-16 inch, from Transco's system near Mooresville across to southeastern North Carolina, $30 million contracts let on 200 miles to C. N. Flagg & Company.

Northern Illinois Gas Company, 140 miles, 24-inch, gas, main line, East Dubuque to Des Plaines, Ill., planned.

Northern Natural Gas Co., Omaha, 167 miles, 20 inch, gas, from Farmington, Minn. to Duluth, Minn., and Superior, Wis., $12 million, before FPC.

42 miles, 10 inch, gas, from Rochester, Minn. to Winona and Goodview, Minn., $963,000, before FPC.

365 miles, gas, new facilities in Minn., Iowa, S. D., Neb., Wis., plus 1090 miles of branch line and station facilities, $65.7 million, authorization for a part. Gas facilities in Texas, Oklahoma and Kansas, $6 million, before FPC.

454 miles, main line loops and extensions, 6-30-inch, main line from St. Cloud, Minn., to Grand Forks, N. Dak., also 1,490 miles of branch lines, 2-10-inch, and station additions totaling 32,000 horsepower, $86 million, planned.

27.6 miles, 30-inch, gas, loop; 18.3 miles north of Beaver station in Okla., 9.3 miles north of Sunray station in Texas, $3 million, authorized.

Northern Utilities Co., 35 miles, 16 inch, gas, in Fremont Natrona County, Wyo., area; 8 miles, 12 inch, around Casper; 6 miles, 8 inch, from Sand Draw gas field to Beaver Creek field; 12 miles, 6 inch, from Beaver Creek field to the system servicing the Riverton-Lander area, planned.

Ohio Fuel Gas Co., 51 miles, gas, main lines, in Belmont, Carroll, Cuyahoga, Fairfield, Logan, Lorain, Marion, Muskingun, Stark and Wayne counties, Ohio, $2.2 million, authorized.

Natural gas storage field in Medina County, Ohio, 12 miles, 4½ to 20-inch gas, $5 million, authorized.

Pacific Gas & Electric Co., 1300 miles, 30-inch gas, from Alberta, Canada to Antioch, Calif., $380 million, planned.

Pacific Lighting Gas Supply Co., 128-mile, 34-inch, gas, main line from Topock, Ariz. to Newberry, Calif., authorized.

Pacific Northwest Pipeline Corp., Salt Lake City, 235 miles gas, gathering lines in San Juan Basin, Garmesa, Piceance Creek, and Big Piney Fields, $13.5 mil-

lion, planned.

65 miles, gas, sales laterals in Washington, $1.5 million, planned.

Pennsylvania Gas Co., Warren, Penn., 38 miles, 8 and 10 inch, gas, in Erie and Warren Counties, Penn., and Chautauqua County, N. Y., $2.6 million, authorized.

Permian Basin Pipeline Company, Omaha, 61 miles, 16-inch, lateral, gas, 11 miles, various diameter, field lines, nine meter stations, to take gas from Emperor field, Winkler County, Texas, $3.7 million, FPC authorization.

Piedmont Gas Co., Hickory, N. C., 78 miles, 2-8 inch, gas, from connection with Transcontinental Gas Pipe Line to serve customers in North Carolina, $2.6 million, authorized.

Pioneer Natural Gas Co., Amarillo, Texas, 62 miles, 10-inch main, Pampa, Texas, to Canyon, in Randall County, Texas, 20 miles, small diameter, gathering, 4,000 h.p. stations, $4.5 million, planned.

Phillips Petroleum Co., 25 miles, 6 to 20-inch, gas, South Eunice, New Mexico area, planned.

52 miles, 4 to 20-inch, gas, Gaines County, Texas, planned.

44-mile, 6-inch, products line, from Rocky pump stations to Amarillo, Texas, planned.

Service Pipe Line Company, Casper, Wyo., 4,000 compressor hp at Herndon, Kans., 2,000 compressor hp at Scranton, Kans., and 2,000 compressor hp at LaGrange, Wyo.; additional 2,000 hp at Laton station, Rocks County, Kans., 2,200 additional hp at Elk Basin, Kirby, Owl Creek, and Lost Cabin stations, north of Casper, Wyo., planned.

Shell Pipe Line Corp., Houston, 43 miles, 8-inch, crude, main and 20 miles, crude gathering, Colorado City, Texas, to Borden-Garza County of West Texas, contract let to Connor Construction Company.

Southern California and Southern Counties Gas Cos., Los Angeles, 200 miles, 34-inch, from Nevada-California border to point near Fullerton, Calif., $44 million, before Public Utilities Commission.

Southern Kansas Pipe Line Co., Inc., Arkansas City, Kansas, 200 miles, 6-10 inch, crude, southwestern Kansas to Arkansas City, Kansas, planned.

Southern Natural Gas Company, Birmingham, 136 miles, 24 and 26 inch; 215 miles, various diameter supply lines; 3,650 additional compressor horsepower to White Castle and Toca Stations; 8 miles, contract let to Conner Construction Co., 20-inch loops; 660 hp Franklinton station, and 23 measuring stations, $40 million, contracts let to William Brothers, Western Pipe Line, Inc., Brown & Root, Inc., and River Construction Corp. on 305 miles.

458 miles, 16-24-inch, loop lines, gas, between Gwinville, Miss., and Wrens, Ga.; 62 miles, 14-inch, loops, along Atlanta-Macon line; 53 miles, 6⅝ to 14-inch, loops, along various branch lines. 3,140 additional hp at Gallion and Elmore, Ala. and Wrens, Ga. 60 miles, 20-inch, loops, in Louisiana between Franklinton and White Castle and South of Toca. Lateral lines south of Gwinville and west to Cranfield field, 8,720 hp added at Franklinton, White Castle, Patterson and Brookhaven. $65 million. contracts let to River Construction Corp., H. C. Price, Latex Construction Co., and Houston Contracting Co. on 355 miles.

Tennessee Gas Transmission Co., Houston, 264 miles loop lines in Tennessee, Kentucky, West Virginia and Pennsylvania, FPC Examiner authorization.

Compressor stations in Mississippi, Tennessee, New York, Pennsylvania and additions in Tennessee, Kentucky, Ohio and Pennsylvania, $129 million, FPC Examiner authorization.

21 miles, 16-inch, 2 miles, 12¾-inch, gas, Louisiana coast, Vermillion, Blocks 46 and 64, $2.9 million, before FPC. 158 miles, 36-inch, looping system in Louisiana and Mississippi, to supply Midwestern additional gas at Portland, Tenn. $61.4 million, before FPC.

Texas Eastern-Penn-Jersey Transmission Corp., Shreveport, La., 65 miles, gas, from Delmont, Penn., to Lambertville, N. J., before FPC.

24,000 compressor hp additions to existing stations, $4.4 million, temporary FPC authorization.

4,000 horsepower to its Delmont, Penn., compressor station, five new compressor stations in Pennsylvania with total capacity of 67,000 hp, $11.2 million, authorized.

Texas Eastern Transmission Corp., Shreveport, La., 267 miles, 14-30 inch, gas, Louisiana, Mississippi, Pennsylvania and New Jersey, $50 million, before FPC.

96.5 miles, 30-inch, gas, between Kosciusko, Miss., and Uniontown, Penn.; 9.4 miles of supply laterals; a 10,250 hp compressor station, and 33,360 hp to existing compressor stations, $24.5 million, authorized.

141,780 additional horsepower in existing stations, a new 2,200 hp compressor station, in Louisiana, Mississippi, Pennsylvania, Ohio, Kentucky and Tennessee, authorized.

10 miles, 8-inch, LPG, Lebanon to Todhunter underground storage in Ohio, 62 miles, 8-inch, Tyler to Carthage, Texas, planned.

Texas Eastern Transmission Corporation and Wilcox Trend Gathering System, Inc., gas, compressor stations, $4 million, authorized.

Texas Gas Gathering Corp., Shreveport, 36.6 miles, gas, gathering system in Rodney Field, Jefferson County, Miss. and from North and South Locust Ridge, Lake St. John Field in Tensas and Concordia parishes, La., $855,413, before FPC.

Texas Gas Transmission Corporation, Owensboro, Ky., 92 miles, 30-inch, 19 miles, 26-inch, and 15 miles, small diameter, loop portions of system in Louisiana, Arkansas, Mississippi, Kentucky, Indiana and Illinois; additional horsepower at Pineville, La., Kenton, Tenn., Calvert City, Ky., Slaughters, Ky., Dillsboro, Ind., and Petersburg, Ind., totaling 9,040 hp, $20 million, authorized.

Texas Illinois Gas Pipeline Company, Chicago, 16,000 additional hp to stations at Lufkin, and Marshall, Texas; Texarkana, Malvern, Searcy, and Biggers, Ark.; Jackson, Mo.; and Hammond. Ill., $3.9 million, before FPC.

Transcontinental Gas Pipe Line Corp., Houston, 204 miles, 36-inch, 107 miles, 30-inch, main line loops in 10 states; 3 intermediate stations: North Carolina, Virginia, Pennsylvania; 2,500 additional hp at six compressor stations; 164 miles, 24-inch from Leidy storage Penn.; 29 miles, 30-inch, New Jersey; gathering lines, Louisiana, 119 miles; 10 meter stations; additions to West Cameron and High Island area, 35-miles, 16-inch, 26 miles, 10-inch, and three gathering meter stations; 45 miles, 16-inch, purchase laterals and 5 meter stations, Louisiana; 67 miles, 10, 12, 20-inch miscellaneous transmission purchase laterals in Texas and Louisiana, 3 meter stations; 51 miles, 36-inch and 1 mile, 30-inch in New Jersey; 51 miles, 10- and 14-inch and 3 meter stations, southeast Louisiana (mainly offshore), $137.3 million. Contracts let on 673 miles to Bechtel Corp., Charman, Allen, Gay & Taylor, Panama Williams, J. P. Neill, H. C. Price, Brown & Root, and Hallmac Construction Co.

151 miles, 24-inch, 12 meter stations, southeast Louisiana, $14.5, authorized.

2,500 additional hp at four compressor stations, St. Francisville, La.; Laurel, Miss.; Linden, Ala. and Wadley, Ala., $3 million, authorized.

Wells, pipe lines, measuring equipment, stations at Leidy storage in Pennsylvania, $12.5 million, authorized.

149 miles, 36-inch, main loops, 34 miles, 20, 24-inch gathering, compressor stations at Neuces County, Texas and St. Helena Parish, La., additional hp in eight stations, $51 million, before FPC.

Trans-Utah Pipeline, 120 miles, 16-inch, gas main line from Uinta Basin to Salt Lake City, considered.

Transwestern Pipeline Company, Houston, 1,305 miles, 24- and 30-inch, gas, main line, from West Texas and Oklahoma-Texas Panhandle area to Topock, Ariz., $193 million, before FPC.

Trunkline Gas Company, Houston, 204 miles, 26-inch, gas, main line from Tuscola, Ill., to Michigan-Indiana border; 464 miles, 30-inch loops between Longville, La., and Tuscola and 45 miles, 24-inch, in Texas, 183 miles gathering, Louisiana, 3000 additional hp at Longville station, $81.5 million, before FPC.

Underground Storage & Exploration, Upper Darby, Penn., 394 miles, 12-inch LPG, from Moundsville, W. Va. to Newark, N. J., $9 million, approved.

95 miles, 6-8 inch, laterals to Mauch Chunk, Penn., and to Philadelphia, planned.

United Gas Pipe Line Co., Shreveport, La., 203 miles, 30-inch, gas, between New Orleans and Mobile, Ala., $33.7 million, contracts let on 30-miles to O. R. Burden, 38 miles to Williams Bros., and 12 miles to Western Pipe Line, Inc.

Valley Gas Transmission, Inc., Houston, 160 miles, 3 to 8-inch, gas, gathering, in Hidalgo, Brooks, Starr and Jim Wells Counties, Texas, $15 million, before FPC.

International

ACT Oils, Ltd., Montreal, 400 miles, crude, Dawson Creek, B. C., to Bella Coola, B. C., before B. C. government.

Alaska-Yukon Refiners and Distributors, Ltd., Edmonton, Alta., 150 miles, products, serving Alaska and Yukon territory, $3.5 million, planned.

Alberta Natural Gas Company (Jointly owned by Westcoast Transmission Co. and Alberta & Southern Gas Co. Ltd.) 36-inch, gas, Alberta border to British Columbia-Idaho border, supply gas to Pacific Gas & Electric Co., $40 million, planned.

Bituminous Oil Pipeline Co., Calgary, 250 miles, crude, from Athabasca tar sand plant in northeastern Alberta to Edmonton, approved.

British Petroleum Co., 60 miles, crude, from deep water tanker terminal at Milford Haven, U. K. to Llandarcy Refinery, $18 million, construction underway.

Burmah Oil Co., Ltd., 850 miles, crude, 20 inch, from Nahorkatiya to Calcutta, India, planned.

Colombian Petroleum Company, 68 miles, 12-inch, crude, Cicuco field to Covenas, planned.

Consolidated Gathering Systems, Ltd., Calgary, 198 miles, crude, Sturgeon field to Edmonton, planned.

Development and Resources Corp., 70 miles, 8 inch, gas, from Agha Jari oil field to Ahwaz, Iran, planned.

Elburz Oil Corp., 1000 miles, crude, from Central Iran to Alexandretta, Turkey, $450 million, planned.

Entre Nazionali Idrocarburi, Rome, Italy, crude, from Qum field in Iran to the Mediterranean Sea, considered.

Foothills Pipe Line, Ltd., 500 miles, 12 to 16-inch, LPG, from Alberta to Pacific Coast, $80 million, considered.

Hydrocarbons Pipeline, Ltd., Winnipeg, Manitoba, 880 miles, 6-8 inch, products, from Edmonton to Winnipeg, $35 million, partial authorization.

Independent Pipe Line Co., 2,019 miles, 34-36-inch, crude, Edmonton to Montreal, 23,000 pump horsepower, $395 million, before Borden Commission.

Interprovincial Pipe Line Company, 350-mile extension from Toronto to Montreal, looping line from Edmonton to Toronto, crude, $240 million, considered.

Mid-Continent Pipe Lines, Ltd., 1500-mile, 30-inch crude, Edmonton to Chicago, planned.

NATO, 211 miles, crude, 6-inch, between Malatya-Cetinkaya-Erzincan, Turkey, $6 million, bids asked.

National Iranian Oil Co., 146 miles, 6 inch, crude, from Azna to Isfahan, Iran, $5 million, planned.

1000 miles, 38 inch, crude, from central Iran to the Turkish Mediterranean coast, considered.

Peace River Oil Pipe Line Co., Ltd., 70-mile, crude, Swan Hills to Iosegun Junction, approved.

Petroleos Mexicanos, 600 miles, 24-inch, gas, from Pemex City to Mexico City, $50 million, construction underway.

38 miles, 4 inch, products, from Mexico City to Toluca, $500,000 planned.

126 miles, 4, 6 and 8 inch, products, from Mexico City to Cuernavaca and Puebla, $2.5 million, planned.

Pipelines of Puerto Rico, Inc., 95 miles, 8-inch, products, Penuelas to San Juan, Puerto Rico, planned.

Sociedad Nacional de Oleoductor, 75 miles, crude, from Santiago-to-Valparaiso, $3 million, planned.

Sui Gas Transmission Co., Multan, Punjab, India, 145 miles, 8-inch, gas, from Sylhet to Dacca, East Pakistan, $9 million, considered.

130 miles, 16-inch, gas, main line, Multan to Lyallpur, planned.

Trans-Europe Pipe Line, 700 miles, 30 inch, main trunk, crude, from Mediterranean to northern Europe, considered.

Trapsa, 475 miles, 24-inch, crude, from Edjele, Tiguentourine, and Zarzaitine fields in eastern Algeria to Tunisian port of La Skhirra on Gulf of Gabes.

Union Gas Company of Canada Limited, 45 miles, 8-inch, gas, main, Stratford to Goderich, Ontario; 10-miles, 8-inch, main, to Amhertburg; 10-miles, 12-inch, lateral, Galt to Brantford, planned.

Westcoast Transmission Company, Ltd., 174 miles, 30-inch, gas, Savanna Creek gas field, Alberta, to British Columbian border, $45 million, planned.

650 miles, crude, from Peace River area to Vancouver, $100 million, planned.

Williams-McWilliams Industries, Inc., New York, 441 miles, 6-inch, crude, Villa Montes, Bolivia to Villa Hayes, Paraguay, considered.

Yacimientos Petroliferos Fiscales, Buenos Aires, Argentina, 621 miles, 12-inch, products, Mendoza to San Lorenzo, Argentina, $19 million, planned.

281 miles, 12¾ inch, crude, Pichanal to San Miguel Tucuman to Techint, S. A., planned.

450 miles, 16-inch, crude, from Neuquen Province to Bahia Blanca, planned.

1300 miles, gas, from Comodoro Rivadavia Field to Buenos Aires, $200 million, agreement signed with Williams Bros. Co.

Pipe Line Contractors May Aid Training Program

The Pipe Line Contractors Association is considering financing a welder training program at the headquarters of the Pipeliners Local Union 798 in Tulsa.

The training program would be on a yearly basis, and if approved by regular members, would mean that approximately seven students would be in training at all times; an expected 75 new welders would be graduated during the one-year period.

The association's contribution toward this project would be approximately $25,000.

Mid-Continent Pipe Line Buys Shell Gathering Lines

Mid-Continent Pipe Line Company has purchased a 2,600 barrel-per-day crude gathering system in the Tatum's field area of Carter County, Oklahoma, from Shell Oil Company.

The lines consist of 23 miles of 2- to 8-inch pipe. Mid-Continent recently laid a 10-mile, six-inch line from a newly acquired gathering station in Tatum's field to tie into the company's line at Tussy, east of Duncan, Okla.

The 33 miles of additional line will increase the company's total system to 2,903 miles.

FPC Authorizes 28-Mile American Louisiana Project

The FPC has authorized American Louisiana Pipe Line Company to construct and operate 28 miles of 12-inch lateral supply line at an estimated cost of $1.5 million.

The new facilities will enable American Louisiana to purchase gas from the Big Lake Field in Cameron Parish, La. It will also receive gas from Pan American Petroleum Corporation and Kerr-McGee Oil Industries, Inc.

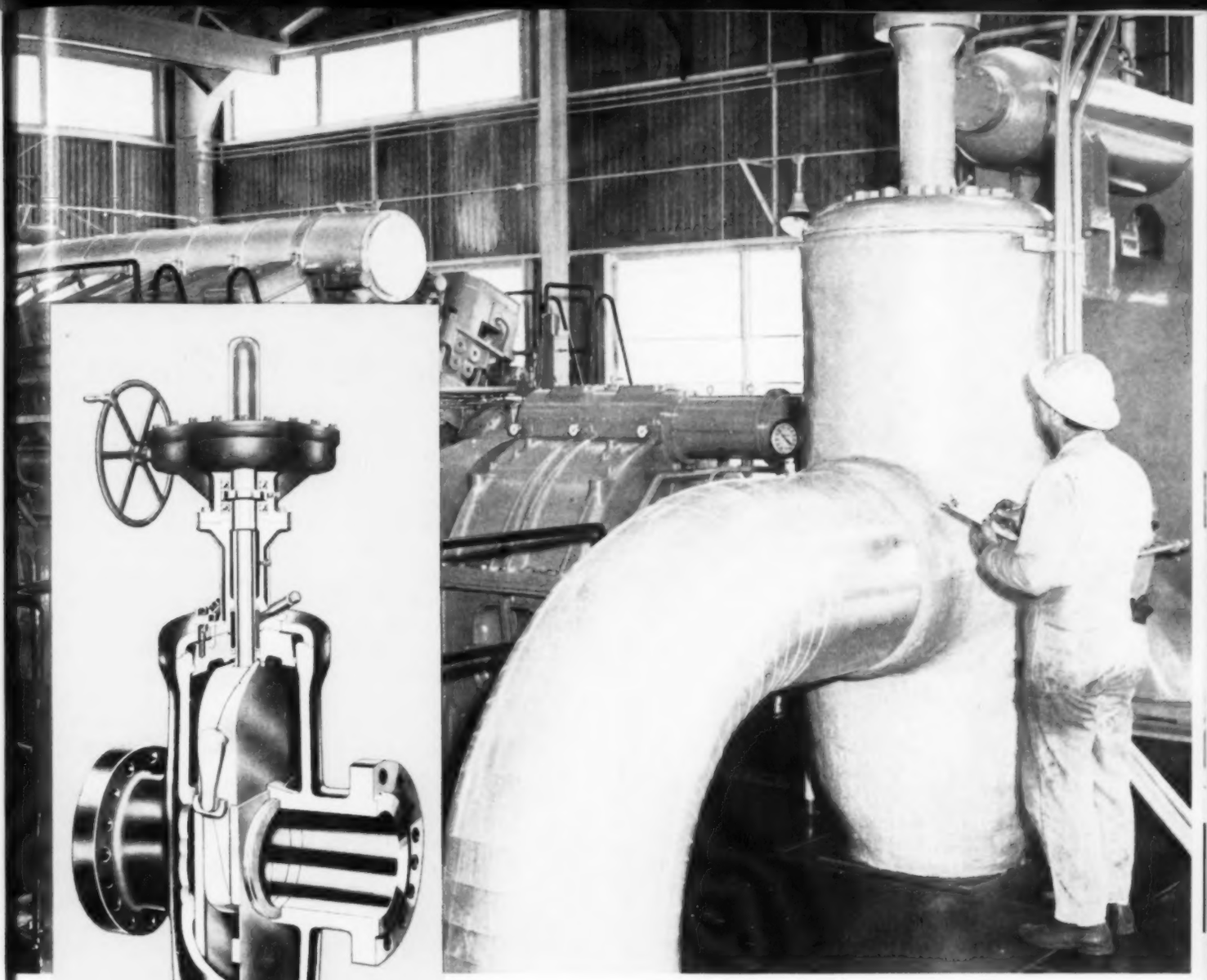
FPC Sets December 15 For Transwestern Hearing

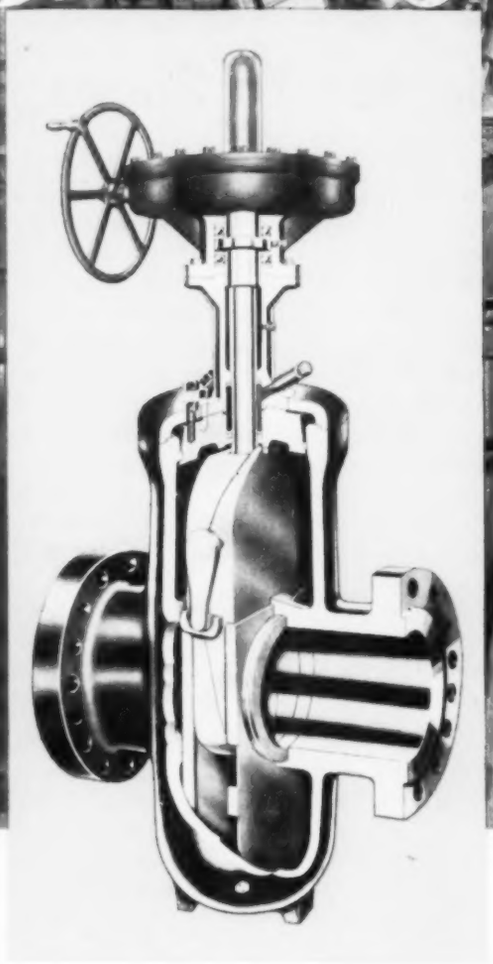
The Federal Power Commission has scheduled a hearing beginning December 15 on Transwestern Pipeline Company's application to construct a gas line from west Texas to the Arizona-California border.

Transwestern proposes to lay about 1,809 miles of various diameter and build 8 compressor stations. The $190 million system will include a 250-mile, 20-inch line from west Texas to Roswell, N. M. and 325-mile, 24-inch line from the Oklahoma Panhandle to Roswell. The main line from Roswell to Topock, Ariz., will consist of 670 miles of 30-inch.

Columbia Gulf Authorized To Acquire Gas System

Columbia Gulf Transmission Company, newly organized subsidiary of Columbia Gas System, has been granted FPC authorization to acquire Gulf Interstate Gas Company's pipe line facilities.





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W-K-M designed this valve to save you time and money. W-K-M valves give you longer service between overhauls, and when overhaul is necessary, you can do the job while the valve is *on-the-line*. This one feature saves users of W-K-M valves thousands of dollars each year.

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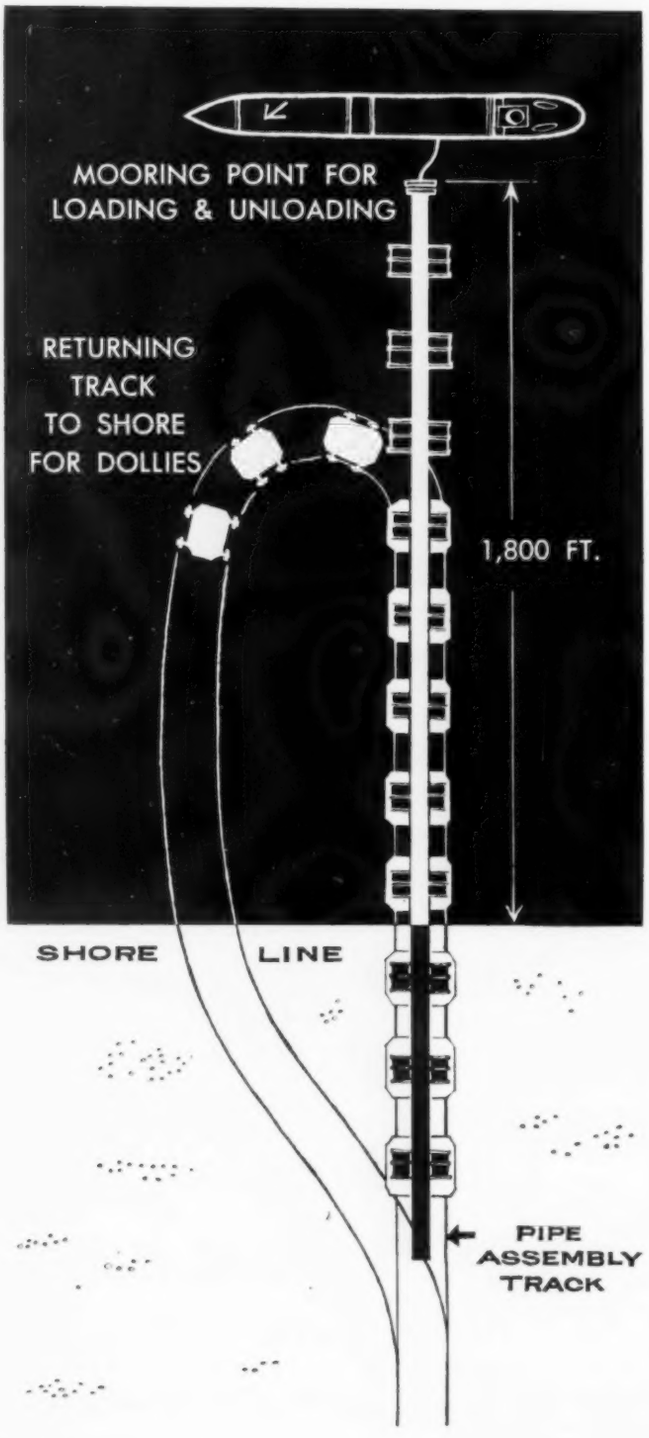
5813

How to do it

PIPE LINE HINTS

$10 is paid for each illustrated acceptable contribution. Mail to The Editor, PIPE LINE INDUSTRY, P. O. Box 2608, Houston 1, Texas

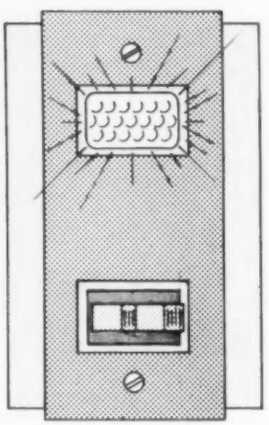
Curved Jubilee Track Returns Bogies To Shore

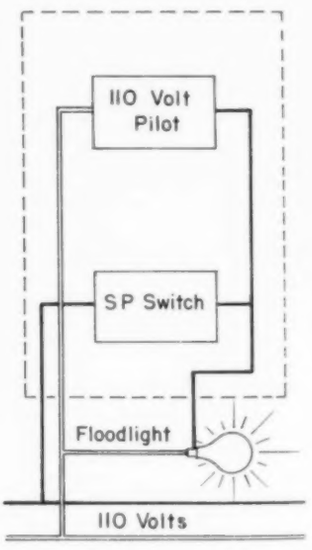


One pipe line company solved an unusual problem in welded fabrication involving a line which extended 1,800 feet into the sea. At the sea end is a length of flexible pipe attached to a buoy, which tankers pick up in order to unload their cargoes through the pipe line.

First the pipe was fabricated into lengths of 600 feet and these lengths were launched by being placed on a series of bogies which ran out to the sea on jubilee track. The track curved around in a semi-circle and then returned to the shore. When the pipe reached deep water, it floated up from the bogies due to the buoyancy of the oil drums which were attached to it at regular intervals. The bogies then returned to the shore around the semi-circular track.

As one section was launched, the next section was lined up and welded to it; this was repeated until the job was completed. Despite the length and weight of the pipe, the whole launching operation took only 13 hours.





Use Red Pilot Light To Control Floodlights

Install a "despard" type switch and a red pilot light in a regular switch box, in a pump station or tank farm office, to control outside floodlights.

A red pilot light will attract attention when the lights are left on after sun-up.

Use Pipe Scraps to Make Hand Winch on Truck Bed

A hand winch which can be fastened to the front of a truck bed can be made with scraps found around the pipe yard. The main winch drum is a piece of 2-inch pipe with a 1½-inch thrust inside it. The 1½-inch pipe is welded to a support, which in turn is fastened to one side of the bed: the 2-inch pipe runs through a support bearing on the opposite side of the truck. A crank is made from ¾-inch pipe and is notched to fit a pin through the end of the 2-inch section.

A piece of 1-inch rope completes the rig. It is hooked to one end of the main drum and wrapped around it to make the reel. When the crank is inserted, a load up to one ton can be lifted onto the pickup truck.

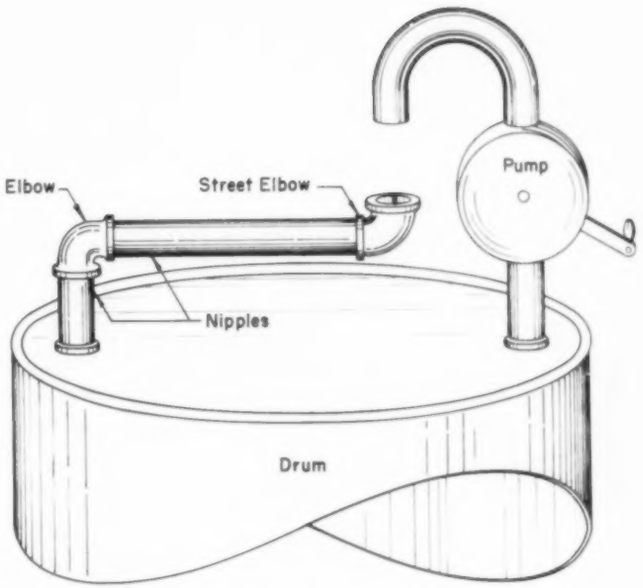
Saw Horse Converted To Tool Storage Box

Where space is at a premium in the tool house, a place for storing small tools may be made between the legs of the saw horse on which the vise is mounted. This keeps everything necessary for piping work around the station in one place and the tools may be locked up when not in use.

The tool box is made simply by boxing up the legs of ordinary saw horses with the front of the doors hinged so that a working platform folds out when the box is opened. Legs for the platforms are made by taking two-by-fours and hinging them at the top so that they swing out and rest on the floor when the tool boxes are opened.

The boxes are small enough so that they may be taken to various jobs, or kept in the main station tool house. Sliding trays are built in the top part with the bottom made into a bin to keep the larger hand tools.

Small Pipe Used as Drain For Hand Pump on Oil Drum



Whenever hand pumps are installed on oil drums, there is always some leakage after they are used. An easy way to stop these drips is to make a drain from standard pipe fittings. All you need is two ½-inch nipples (TBE), a 90-degree standard elbow and a 90-degree street elbow (see sketch). The street elbow acts as a funnel to keep the oil dripping from the pump running back into the drum without making a mess. The ½-inch fittings turn freely in the drum and swing out of the way when the pump is in use.

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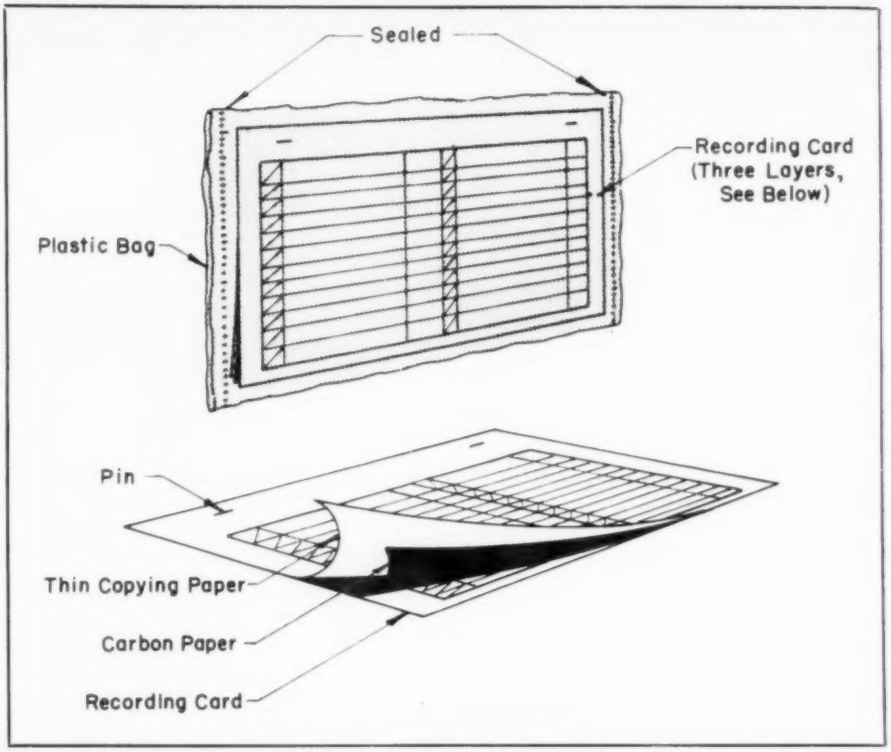
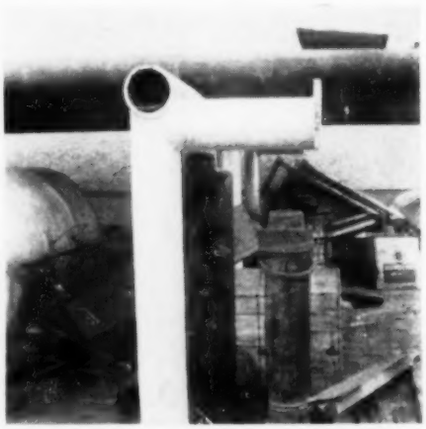


Plastic Cover Protects Records From Dirt

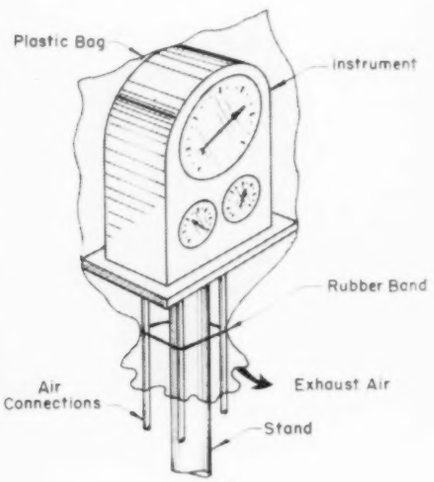
Records are often kept at the site of pumps or other equipment. It is nearly impossible to keep these record sheets clean because of splash and dirt from the operators hands.

One way to keep records clean is to seal the record sheet, together with a duplicate and carbon paper between, in a plastic bag. A pencil or ball point pen will make a permanent, clean copy of the record through the carbon paper.



Extension on Pipe Rack Makes Loading Easier

Loading on the pipe racks can be easier through the use of an extension made of 4-inch pipe as shown in the accompanying photograph. This extension is approximately the width of a 12-inch plank. This plank can be placed on this pipe bracket and extended to the truck bed. The pipe can then be rolled onto the rack with considerably less effort than present procedures.



Plastic Bag Protects Instrument From Corrosion

To protect local transmitters or other instruments from corrosion in a corrosive atmosphere, select an adequate-size plastic bag and cover the instrument to be protected, as shown. A rubber band will hold the bag in place, and exhaust air from the instrument will continuously purge the inside of the bag.

Introducing the
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What's Happening

among MEN in the INDUSTRY

Burt E. Hull, Mr. Pipe Liner, died in Dallas November 8. He was 74.

He will be remembered for the many giant steps which the pipe line industry took under his leadership. Builder of over 10,000 miles of line in his 46-year career with the Texas Company, he engineered many outstanding projects including the War Emergency Big Inch crude and Little Big Inch products lines and the Trans-Arabian 30-inch crude line. The latter, built in 1951, is the world's largest crude line.

Burt Hull was a natural leader, good organizer and was able to gain the confidence and loyalty of his workers. He was able to delegate authority to his subordinates; his crews took pride in being called "Burt Hull's Boys."

In a remarkable pipe line career, Hull served as president of the Texas Pipe Line Company, Trans-Arabian Pipe Line Company, Texas-New Mexico Pipe Line Company, Texas Empire Pipe Line Company, Kaw Pipe Line Company, and vice president of the Texas Company. After retiring from Texaco in 1951, he remained a pipe line consultant.

A native of Navasota, Texas, Hull was a 1904 graduate from Texas A & M with a degree in engineering. In 1905 he joined the Texas Company pipe line department. That year he was sent to Beaumont as acting pipe line engineer and later he was assigned to Oklahoma Indian territory to survey the route for an 8-inch line to Humble, Texas.

He was named manager of the company's Mexican subsidiary in 1922 and in 1926 he returned to Houston to become president and a director of the Texas Pipe Line Company.

Possibly his greatest single achievement was the construction of the Big Inch pipe line in 1942. "Burt Hull's Boys" completed construction of the 24-inch, East Texas to Linden, N. J., line in one year. With this line in operation, tankers from Gulf Coast and East Coast were available for supplying armed forces in the Normandy invasion. The 20-inch Little Big Inch line, which runs from the Gulf Coast to Lebanon, Ohio, is the largest products pipe line now in operation.

Two years after the war, the master builder departed for Saudi Arabia to build the Trans-Arabian crude line extending from the Persian Gulf fields to Sidon, Lebanon. With Tapline completed he returned to Houston and retired.

Hull leaves behind him a great list of engineering contributions to the pipe line industry, an outstanding reputation, and thousands of friends throughout the industry.

Bert E. Hull

Karl E. Schmidt, vice president and engineer of **Michigan Consolidated Gas Company,** recently received an honorary doctorate degree from Wayne State University during the 25th anniversary of the school's College of Engineering.

Schmidt has been with Michigan Consolidated since 1936 and in 1948 became a technical assistant in the Engineering department. He became engineer in 1952 and was elected vice president in 1953.

Dudley L. Rankin, a 35-year veteran of the oil industry, has been chosen to serve on the international staff of the North Atlantic Treaty Organization in Paris.

D. L. Rankin

Rankin, manager of **Wyco Pipe Line Company**, will become chief of the Petrol-Oil-Lubricant section of the NATO staff. His temporary assignment is for 18 months. Rankin will be in charge of the specifications for construction and inspection of military petroleum product pipe line facilities in European countries participating in the NATO alliance.

He was with Standard Oil Company of Indiana for 28 years and the past seven years has been at Wyco.

Otis G. Bryant has been promoted to chief engineer for **Houston Pipe Line Company.** He will be responsible for planning, design and construction of all new pipe lines and related facilities, and will furnish general engineering and technical services to management and other departments.

Bryant joined Houston Natural Gas Company, parent company of Houston Pipe Line, in 1949. He was made senior engineer for the pipe line firm in 1957.

Walter Shannon has been named director of Pipe Line Engineering for **Gulf Oil Corporation.** Shannon formerly was vice president and manager of operations for **Gulf Refining Company.** His responsibilities will include counseling Gulf, its subsidiaries and affiliates regarding new developments in pipe line design, facilities, construction, operation and maintenance. Shannon will design new pipe line systems, review contractor proposals, recommend preferred contractors and award contracts.

Walter Shannon

He joined Gulf in 1920 and became chief dispatcher in 1940. In 1949 he was named general superintendent of Gulf's Pipe Line department. Shannon was appointed vice president and manager of operations for Gulf Refining Company in 1957. His headquarters will be in Pittsburgh.

Natural Gas Pipeline Company of America and **Texas Illinois Natural Gas Pipeline Company** announce three changes in station superintendent personnel.

Kenneth L. Bishop succeeds **Charles L. Cochran** as superintendent on TING station 302 at Conroe, Texas. **Vernon L. Ebeling** succeeds Bishop at NGPL station 102, Gray, Okla.; and **Ted Cheuvront** becomes superintendent of NGPL station 56, Mt. View, Okla.

Hailey A. Roberts has been named assistant to the secretary of the **Pipe Line Contractors Association**. Roberts, formerly with Office of Special Investigations, Washington, D.C., will assist **Richard A. Gump.**

C. R. Rikel has been promoted to executive assistant in the Southern California Gas Company, reporting to senior vice president **R. R. Blackburn.** He succeeds **G. H. Pickett** who was recently appointed manager of procedures analysis. Formerly central division sales manager, Rikel will be responsible in his new assignment for building coordination, insurance, and preparation of the capital budget for the company.

C. R. Rikel

Southern Union Gas Company announces two managerial changes in its operating districts. **E. C. Reddy,** formerly Albuquerque district manager, becomes manager of the El Paso district. **C. A. Stockhoff,** who had been Albuquerque sales manager, replaces Reddy.

Reddy, who succeeds **Davis Butler,** will be in charge of all phases of operations in El Paso and Alamogordo, N. M. Butler is now manager at Roswell, N. M., for Lee County Gas Company. Reddy has been associated with Southern Union since 1929. Stockhoff will be responsible for operations in Albuquerque, Belen, Bernalillo and Los Lunas. He has been with the company since 1957.

Interstate Oil Pipe Line Company announces several promotions. **Sequoyah H. Brown,** a director of the company since 1953, has been elected a vice president. **Frank R. Clark, Jr.,** secretary and tax attorney, has been named treasurer. **F. Roy Ball** has been appointed manager of the Material-Traffic department succeeding **H. P. Hellinghausen.**

Brown, who has been with the company since its inception in 1945, formerly was employee relations manager. Clark joined Interstate in 1945 and will continue to handle corporate secretarial matters along with his new assignment.

Ball was associated with **Oklahoma Pipe Line Company** which later became Interstate and Ajax Pipe Line Corporation before joining Interstate. In 1946 he was named division manager of material-traffic for Interstate. In 1951, he became assistant manager of the department. **Robert B. Giezentanner** succeeds Ball as assistant manager. Hellinghausen joined Oklahoma Pipe Line Company in 1917. He was made a director in 1930. In 1945 he became treasurer of Interstate and in 1951 became manager of material-traffic.

E. H. Tollefson, executive vice president of **Consolidated Natural Gas Company,** has been elected chairman of the board of trustees of the Institute of Gas Technology at the 17th annual meeting October 29 at Illinois Tech.

Lester Potter, president **Lone Star Gas Company,** and **Charles M. Sturkey,** president **Washington Natural Gas Company,** have been elected to three-year terms on the board. **Milton J. Pfeiffer,** vice president of gas operations, **Cincinnati Gas and Electric Company; Linn Bowman,** vice president of gas operations, **Rochester Gas and Electric Corporation;** and **F. S. Cornell,** executive vice-president, **A. O. Smith Corporation,** have been selected to fill vacancies on the board in 1959. **R. J. Rutherford,** president **Worcester Gas Light Company** has been elected to a two-year term.

Tennessee Gas Transmission Company announces three changes in its exploration department. **W. C. Tillett** has been transferred from Houston to Midland, Texas, as manager of the company's southwestern exploration division.

R. C. Honea, formerly division exploration manager at Midland, has been named staff geologist and has moved to Houston. **E. T. Creegan** has been transferred to Wichita Falls, Texas, as district exploration manager.

WHO'S MEETING WHERE

December

Rocky Mountain Gas Association Annual Meeting, Denver, Colo., Dec. 30.

January

NACE, Canadian Eastern Regional meeting, Montreal, Quebec, Jan. 12-14.

Pipe Line Contractors Association, annual convention, Americana Hotel, Bal Harbour, Fla., Jan. 12-15.

NACE, Houston Section, annual short course in fundamentals of corrosion control, University of Houston, January 22-23.

Texas Society of Professional Engineers, annual convention, Shamrock Hilton Hotel, Houston, January 22-24.

Annual Midwest Welding conference, sponsored by Armour Research Foundation of Illinois Institute of Technology, and American Welding Society, Chicago section, Illinois Institute of Technology, Chicago, January 28-29.

February

American Society for Testing Materials, D-2 committee on petroleum products and lubricants, Sheraton-Jefferson Hotel, St. Louis, February 1-6.

Southwestern Legal Foundation, 10th annual institute on the law of oil, gas, and taxation, Southwestern Legal Center, Dallas, February 11-13.

NACE, Corrosion Short Course, Mayo Hotel, Tulsa, February 11-13.

NACE, Canadian Western Regional meeting, Calgary, Alberta, Feb. 12-13.

ASTM, Southwest District, annual meeting, Engineering & Scientific Society, Houston, February 26.

Natural Gasoline Association of America, Permian basin regional meeting, Scharbauer Hotel, Midland, Texas, February 27.

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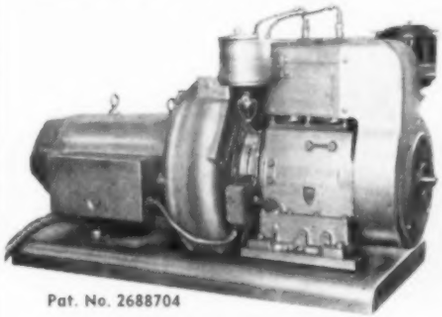

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Quoted from Mr. Dillard Stokes' Column, Shreveport Journal, Oct 13, 1958..
"President Jefferson feared the justices some day would do what they now are accused of. A few months before he died President Jefferson wrote: 'There is no danger I apprehend so much as the consolidation of our government by the noiseless, and therefore unalarming, instrumentality of the Supreme Court'."

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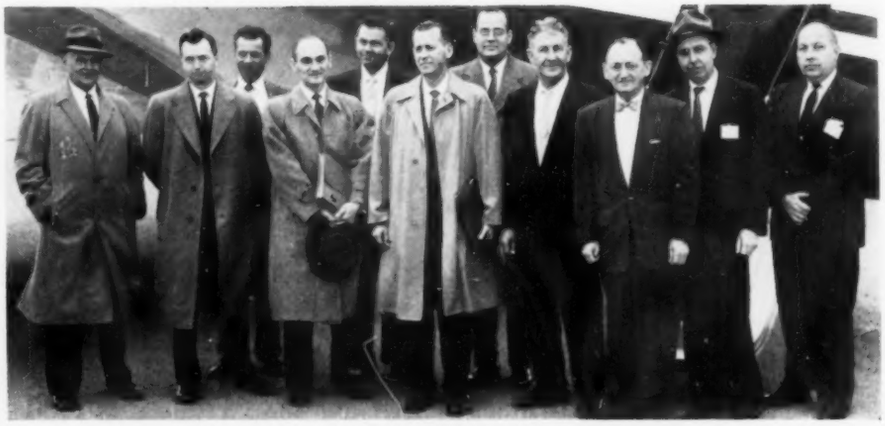
Kelley Ripper Division Names Don V. Stone Manager

Crutcher-Rolfs-Cummings announces the appointment of Don V. Stone as manager of the Kelley Ripper Division of C-R-C. The new division has been organized to serve in the promotion and sales of rippers through Caterpillar dealers throughout the world.

Stone formerly was in sales works for Caterpillar Tractor Co. for 19 years and with Euclid Division of G.M.C. for two years.

Don V. Stone

What's Happening among SERVICE and SUPPLY MEN



Gas Turbine Operations Committee Visits Clark Bros.

Members of the Gas Turbine Operations Committee, a group representing the oil, gas, chemical and petrochemical industries, recently visited the plant of Clark Bros. Co. Purpose of the visit was to inspect manufacturing facilities and discuss gas developments with engineering personnel. From left to right: J. J. Rosecky, Clark Bros.; R. J. Parks, Aramco; J. E. Fenex, Petroleum Chemicals Inc.; J. E. Leo, Trans-Arabian Pipeline Co.; C. A. Falkenhagen, Tennessee Gas Transmission Co.; G. H. Ewing, Texas Eastern Transmission Corp.; A. H. Carameros, El Paso Natural Gas Co.; F. A. Cramer, Southern Counties Gas Co.; M. M. Heller, United Gas Company; R. M. Greene and R. J. Speers, Clark Bros. Co.

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Electrical Mechanical Division

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United States Steel Corp. Elevates J. E. Shoemake

J. E. Shoemake has been appointed manager, pipe line and refinery sales of United States Steel's Oil Well Supply Division with headquarters in Houston.

Shoemake has been with U.S. Steel since 1945 when he was named district engineer at Shreveport, La. He became district engineer, pipe line and refinery equipment in Houston, 1946, and area manager in 1952.

J. E. Shoemake

Santilli Becomes Manager Of Marketing Services Section

Joseph F. Santilli, Jr., has been appointed manager of the marketing services section of Atlas Powder Company's Aquaness department, Houston. He will be responsible for advertising, sales promotion and sales administration work for Aquaness, which markets Atlas' chemicals used in petroleum industry.

Santilli previously served in Atlas' chemical division's advertising and sales promotion department. He formerly was assistant advertising manager of Pennsalt Chemicals Corp.

John S. Kline Appointed Assistant General Manager

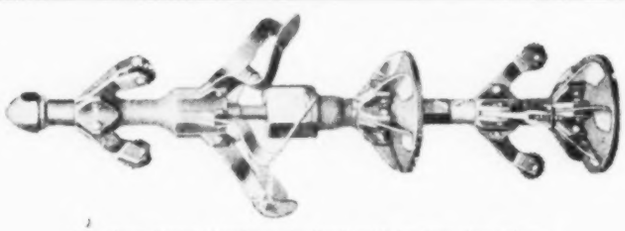
The Carpenter Steel Company announces the appointment of John S. Kline as assistant general manager and chief executive of the company's Alloy Tube Division. Kline has been with Carpenter since 1945 and had been auditor in the firm's main office until 1952. Previously he had worked eight years for Metropolitan Edison Co. P. L. Coddington, general manager of Alloy Tube Division, will continue in an advisory capacity to Kline until retirement next year.

C. Lee Cook Company Appoints Hershberger Sales Representative

V. R. Hershberger has been appointed sales representative for C. Lee Cook Company for eastern Ohio.

Hershberger has been in the field of sales engineering for the past seven years. Previously he served as a mechanical engineer for the Indianapolis Power and Light Company for 14 years.

Go-Devil



Standard Model Northrup Go-Devil with leather disc drivers

G. A. COTTEN CO.

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NORTHRUP GO-DEVILS & TRANSIT PIPE LINE SCRAPERS

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New CROUSE-HINDS EXPLOSION-PROOF MERCURY VAPOR LIGHTING FIXTURES

For dependable security at low operating cost in hazardous locations . . .

- *where long burning hours without interruption are involved, month in, month out*
- *where labor cost or trouble of relamping is an important factor*
- *where maximum lighting output calls for maximum economy in power consumption*

The longer life of mercury vapor lamps is well established: 7000 hours, *vs.* 1000 hours for incandescents. Light output is 2.5 times greater; 55 lumens/watt, *vs.* 22 lumens/watt for incandescents.

The new EV's place these economies within easy reach. As with all Crouse-Hinds explosion-proof devices, EV's are heavily constructed to withstand the pressure of internal explosions without rupturing. Gas-tightness is *not* a requirement for their safe performance. Flame-tight joints prevent the escape of flames to flammable atmospheres.

- *For full information, call your Crouse-Hinds distributor, or write for catalog sheet.*

TYPE EVA Explosion-Proof Lighting Fixture

Available with or without guard, or reflector (dome, deep bowl, shallow bowl, angle, or high bay)

250 Watt— National Electrical Code: Class I, Groups C & D

400 Watt— Class I, Group D

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De Laval Steam Turbine Co. Forms International Subsidiary

De Laval Steam Turbine Company, announces the formation of a wholly-owned subsidiary, Compania De Laval Turbina International, S.A. with offices in Panama, R de P.

The new firm will coordinate and promote sales and servicing of De Laval products throughout the world except in the United States, Canada, Hawaii and Puerto Rico. De Laval also established De Laval Turbine de Mexico, S.A., subsidiary of the Panamanian company, with headquarters in Mexico City.

Richard Cahill is president of the International company and J. P. Stewart becomes president of De Laval Turbina de Mexico.

John Wood Co. Elects Chaffee Vice President

Walter C. Chaffee has been elected vice president and director of engineering for John Wood Company's Bennett Pump Division.

W. C. Chaffee

Chaffee has been Bennett's director of engineering since joining the firm in 1956. Prior to his affiliation with Bennett he had been with Keller Tool Company, Curtis Wright Corporation, Douglas Aircraft Company and his own engineering consulting firm.

International Harvester Co. Promotes Bechman, Bennett

W. O. Bechman has been named assistant to general manager, and Merrill R. Bennett is the new manager of engineering of the Construction Equipment division for International Harvester Company.

Bechman will study needs of the industry and make recommendations for improvements and new design to division management. Formerly manager of engineering, Bechman has been with the company since 1917. He was named chief engineer of Industrial Power division in 1941 and in 1949 became chief engineer of advanced engineering. He was appointed manager of engineering in 1950.

Bennett, who succeeds Bechman, had been assistant manager of engineering. He began his career with the company in 1934 as products tester and in 1943 was named engineer in charge of military prime mover design. He became assistant manager of engineering in 1952.

Pittsburgh Coke & Chemical Co. Promotes Dr. Wesley D. Schroeder

Pittsburgh Coke & Chemical Company has promoted Dr. Wesley D. Schroeder to manager-product research for activated carbons and industrial chemicals in the Research department.

Schroeder joined the company in 1951 as supervisor-plasticized research and in 1955 was named supervisor-industrial chemicals research, the position held until his recent promotion. Before coming to Pittsburgh Coke & Chemical, he had been associated with The Dow Chemical Company and Rohm & Haas Company.

Jack Slough and James DeFlon Form Cooling Tower Company

Jack M. Slough and James G. DeFlon have formed a new cooling tower engineering company, Slough-DeFlon.

Slough had been with Fluor Corporation for six years, in charge of research and development of the Manufacturing division. He was also a sales manager of Sante Fe Tank and Tower of Texas.

DeFlon previously was with Fluor Corporation as manager of research and development. He also had been chief engineer for Sante Fe and Tower Company and in 1949 was sent to Europe to initiate the English firm of Head-Wrightson in the cooling tower field.

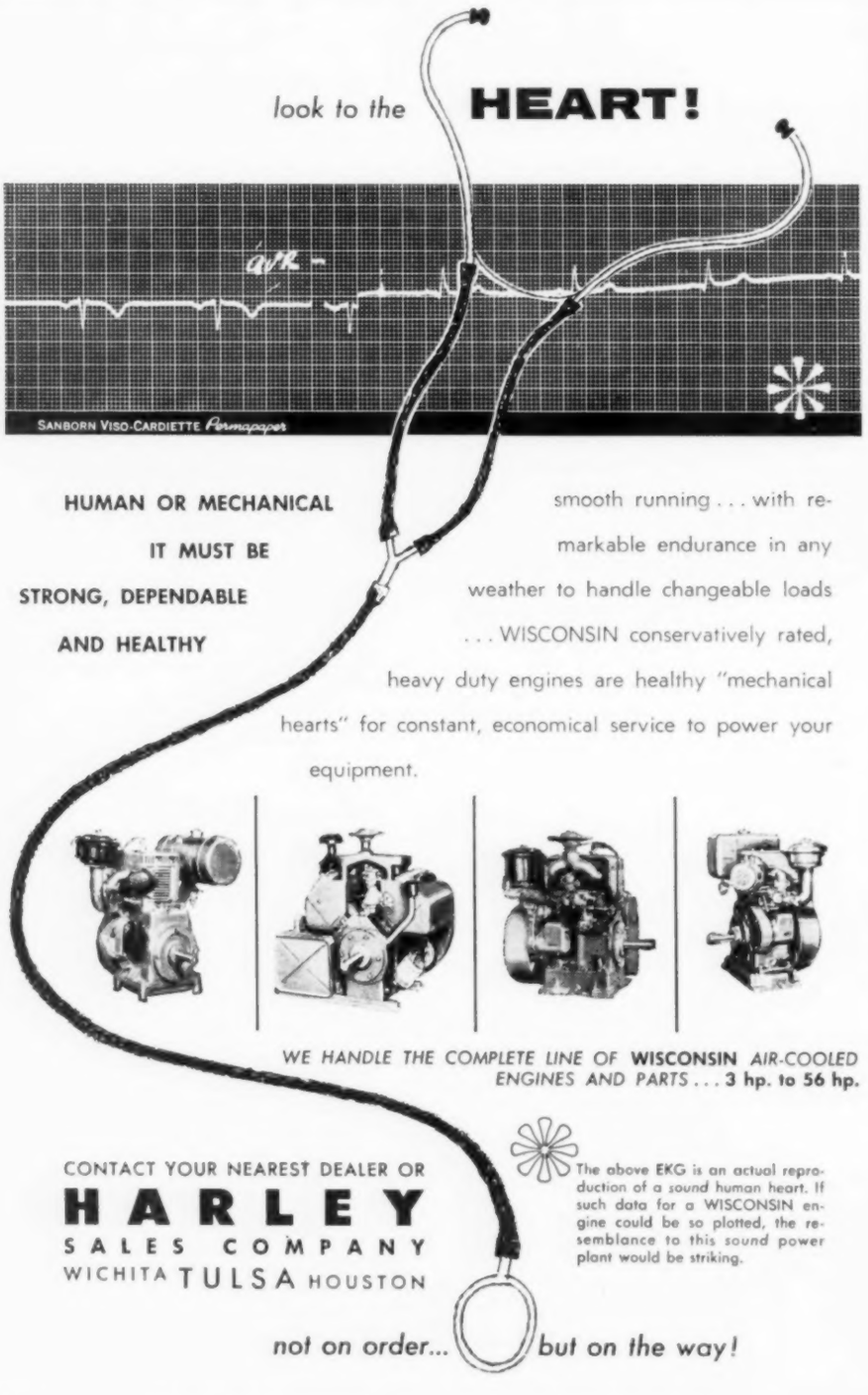
Harco Corporation Occupies New Headquarters

The Harco Corporation recently moved into its new headquarters at 4600 East 71st Street, Cleveland. The combined executive offices and manufacturing facilities are more than five times those formerly occupied by the company.

The company supplies job-engineered systems, materials and contract installations that combat the electrolytic corrosion of buried or submerged metallic structures and pipe lines by reversing the electrochemical force that normally destroys ferrous metals.

Charles Clark Appointed Sales Engineer for Clark

Charles Clark has been named sales-engineer for Clark Bros. Company's Pittsburgh office and Jay B. Williams has been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SANBORN VISO-CARDIETTE Armagapar
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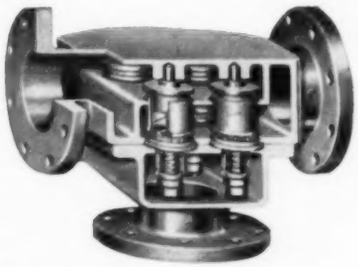
STRONG, DEPENDABLE
AND HEALTHY
smooth running . . . with remarkable endurance in any weather to handle changeable loads . . . WISCONSIN conservatively rated, heavy duty engines are healthy "mechanical hearts" for constant, economical service to power your equipment.
WE HANDLE THE COMPLETE LINE OF WISCONSIN AIR-COOLED ENGINES AND PARTS . . . 3 hp. to 56 hp.
CONTACT YOUR NEAREST DEALER OR
HARLEY
SALES COMPANY
WICHITA TULSA HOUSTON
The above EKG is an actual reproduction of a sound human heart. If such data for a WISCONSIN engine could be so plotted, the resemblance to this sound power plant would be striking.
not on order... but on the way!

AMOT Engine Controls



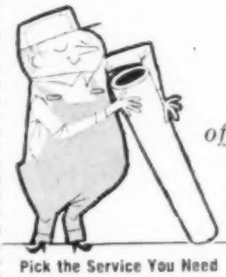
AMOT is the best known name in controls for pipe line engines, and many pipe line companies have up-dated their installed equipment with the **AMOT CONTROLS** listed below.

- **THERMOSTATIC VALVES**
  For jacket water and lube oil temperature control.
- **MECHANICAL SAFETY CONTROLS**
  Shut down engine on high water temp. or low oil pressure.
- **SAFETY CONTROL SWITCHES**
  Sound alarms on high water temperature or low oil pressure.
- **VENTED DIAPHRAGM GAS VALVES**
  Shut off main gas supply to gas engines.
- **THERMOSTATICALLY ACTUATED AIR VALVES**
  For automatic fuel change over.

AMOT MAINTAINS REPRESENTATIVES IN PRINCIPAL CITIES
CATALOG AVAILABLE ON REQUEST

AMOT CONTROLS CORP.

FIRST ST. & NEVIN AVE. RICHMOND, CALIFORNIA



PIPE LININGS

offers you **"ONE SOURCE"** *for Dependable Pipe Line Protection & Reclamation*

Pick the Service You Need	In Our Plant	On Your Site	"In Place"	Pipe Sizes From	To
Cement Mortar Lining of Interiors – Tate Process	..	X	X	4"	16"
Cement Mortar Lining of Interiors – Centriline Process	..	X	X	16"	144"
Centrifugal Spinning of Cement Mortar Lining of Interiors	X	..	..	4"	30"
Centrifugal Spinning of Coal Tar Linings of Interiors	X	X	..	36"	144"
Somastic® Coating	X	X	..	½"	30"
Concrete Coating	X	..	..	4"	30"
Wrapping	X	X	..	4"	30"
Reclamation:					
Removal of Old Wrapping	X	X	..	2"	30"
Straightening	X	X	..	2"	30"
Blasting (Interior or Exterior)	X	X	..	2"	30"
Beveling	X	X	..	2"	30"
Roll Welding	X	X	..	2"	30"
Testing	X	X	..	2"	30"

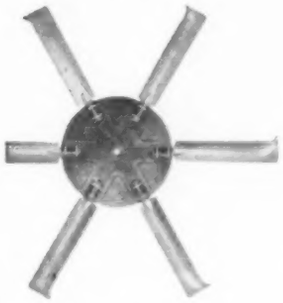
write today for full information

PIPE LININGS A Division of American Pipe and Construction Co.

2414 East 223 St. (P.O. Box 457) • Wilmington, California

"HIGH and mighty"

move mountains - of AIR!
in towers and exchangers



- **Sizes 14' to 18'**
- **4 or 6 blades**

Developed originally for the petroleum industry, Aerovent Large-Diameter "Al-metal" Propellers, constructed of tough, durable aluminum alloy, move great quantities of air at high velocities, in heat exchangers and cooling towers. Pictured above are two 4-blade, 16-ft. propellers in a cooling tower installation. These mighty propellers, with adjustable-pitch "Macheta" Airfoil blades, are job-engineered to individual specifications.

Write for free Bulletin 510

DESIGNED FOR DEPENDABLE OPERATION!

Endurance tests, conducted at *3 times* normal loading prove the ability of these new large-diameter propellers to withstand severe punishment. Heavy-duty cast steel hubs offer maximum resistance to stresses. Angle settings for each operating requirement, and appropriate alternate settings, assure accurate pitch for any predetermined performance which may be required. 54" to 144" now available in revolutionary new "T-Alloy".

REFINERIES, pumping stations, industrial plants and commercial buildings use Aerovent "Al-metal" Propellers in major air-moving applications.

Aerovent **FAN COMPANY, INC.**
LARGE PROPELLER DIVISION
304 Wright Bldg. TULSA 3, OKLA.
Main Office and Factory PIQUA, OHIO

appointed manager of Clark's new Denver branch office.

Clark is a third generation descendant of the original founders of the company. Previously he served six years with Bradbury Kenrick Associates, manufacturer's agents for Clark Bros. Williams formerly was assistant manager of the Tulsa office.

Tableman Named Manager W-K-M Valve Co. Limited

Glen Tableman has been appointed manager of W-K-M Valve Company Limited.

Prior to his new appointment, Tableman had been general sales manager of the W-K-M division in Missouri City, Texas.

Cook Electric Elects Welsh Vice President

Cook Electric Company has elected William T. Welsh vice president and general sales manager. Welsh resigned from Raytheon Manufacturing Company to accept the new position.

He had spent 18 years with Raytheon. The new officer is a member of the Executive Research Business and Defence Services Administration, Washington, D.C.

H. C. Capshaw Promoted By Spartan Aircraft Company

H. C. Capshaw has been promoted to industrial sales manager of the mobile homes division of Spartan Aircraft Company.

Capshaw will head the industrial sales activities of the company's mobile homes division directed toward supplying mobile units for a wide range of uses for on-the-site housing requirements.

P. S. Hurt

T. E. Kraner

Kraner, Hurt Promoted By Cooper-Bessemer Corp.

T. E. Kraner has been named president of Cooper-Bessemer's newly acquired C-B Southern, Inc., Houston engineering firm, and Phil S. Hurt was promoted to assistant product manager, gas engine compressor sales, for Cooper-Bessemer.

Cooper recently purchased Creole Engineering Corporation as an engineering and manufacturing subsidiary and renamed it C-B Southern, Inc. Kraner formerly was district manager in Caracas, Venezuela.

Arthur R. Pitkin Receives Appointment With Tex-Tube, Inc.

Arthur R. Pitkin has been appointed purchasing agent for Tex-Tube, Inc. He will be responsible for purchasing all maintenance supplies and raw materials for production. Pitkin is a member of the National Association of Purchasing Agents, American Society of Tool Engineers and Industrial Management Society.

Puffer-Sweiven Company Forms Beaumont Office

Puffer-Sweiven Company, southern Texas sales representatives for Fisher Governor Company, has established a sales office in Beaumont with Joe Meek as manager. Meek has been with the firm for two years and has a wide instrument selection and sales experience in Texas oil producing area.

Southern Pipe & Casing Promotes C. E. Lamar

C. E. Lamar has been promoted to assistant sales manager for Southern Pipe & Casing Co. division of U. S. Industries, Inc.

Lamar has been in engineering and sales at Southern for seven years.

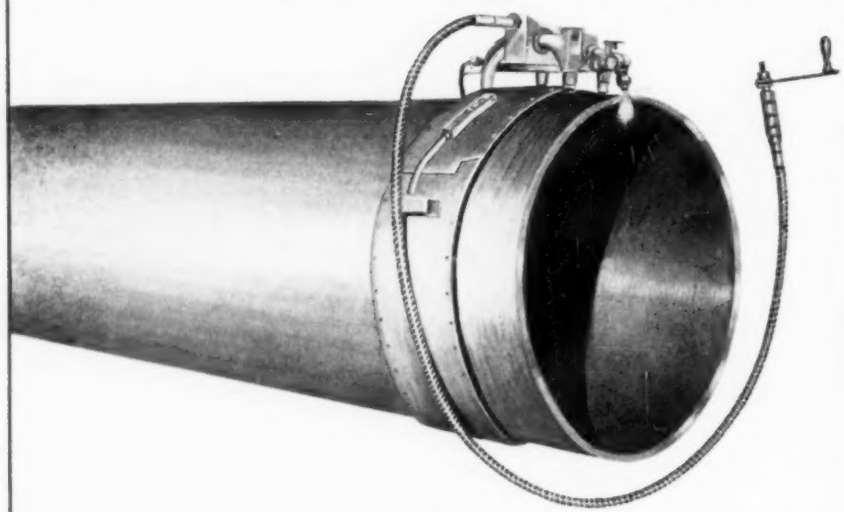
Glasscock Joins White Diesel As Sales Representative

Edward H. Glasscock has joined White Diesel Engine division of the White Motor Company as sales representative in the New Orleans region. His district will include Louisiana, southern Arkansas, Mississippi and Alabama.

Glasscock had been active in distributor organizations for other diesel manufacturers.

BEVELS 6" PIPE

BEVELS 48" PIPE



C-R-C IMCO BEVELERS fit all pipe sizes 6" to 48" O. D., cut perfect bevels, and out-of-round pipe, too. Single lightweight unit does work of several, costs you less to buy and use.

ONE BEVELING KIT FOR ALL YOUR JOBS!

For additional information see page 108, Pipeline Composite Catalog.

The CRC IMCO Pipe Beveling Kit contains a complete range of bands for beveling a variety of pipe sizes. With this convenient selection of sizes, the operator need only make one trip to handle all pipe beveling requirements including back beveling. The sturdy steel case and number of bands are optional.

CRC

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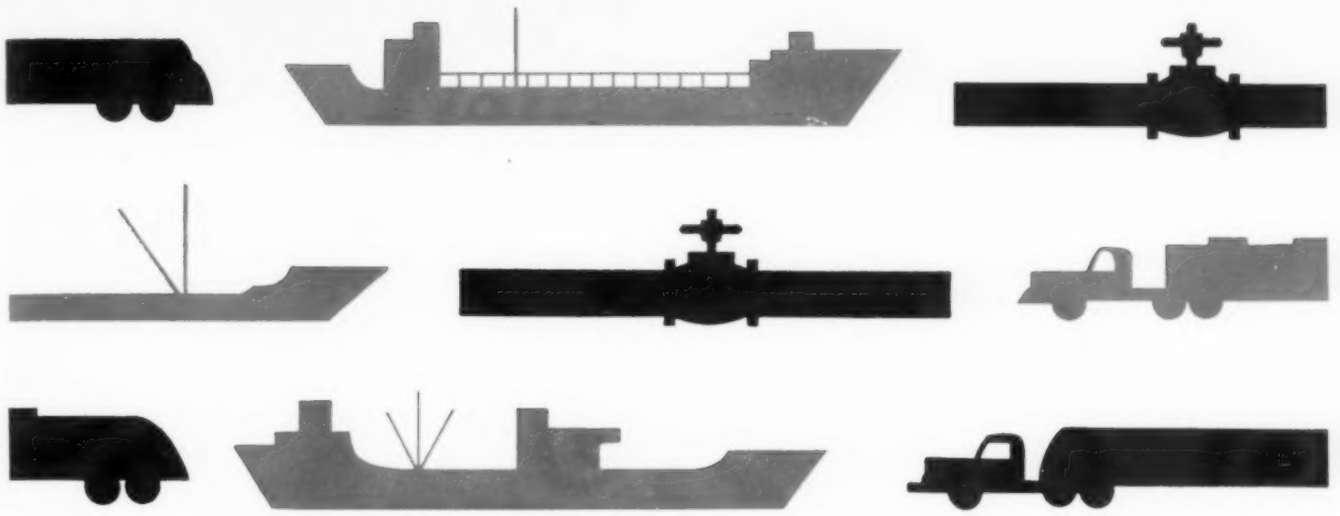
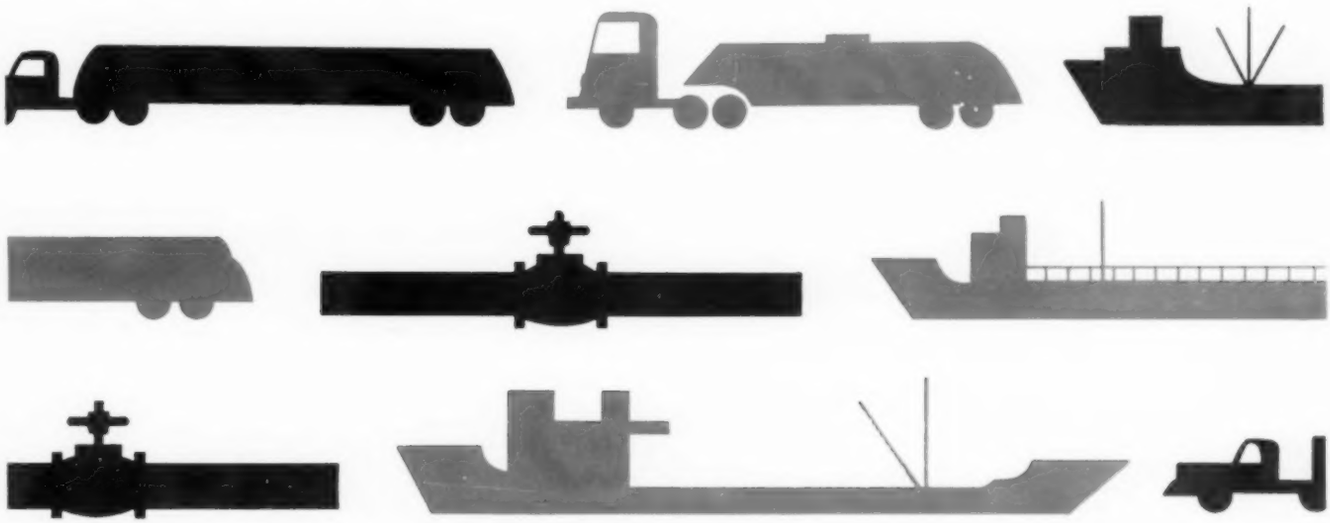


FOR SAFE TRANSPORT-LAND AND SEA

SHAND AND JURS TANK FITTINGS



For over 35 years, Shand and Jurs has pioneered in the design and manufacture of mechanical tank fittings for truck tanks, marine tankers and pipeline installations. S&J offers petroleum transporters the world's most complete line of valves, gages, fittings and controls for maximum safety and economy in the movement of petroleum products. Convenient Shand and Jurs branch offices and sales representatives are ready now to help you with your tank fitting problems. Call them today.

SHAND AND JURS

GENERAL PRECISION EQUIPMENT CORPORATION GPE

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For more data on advertised products, use Readers' Service Cards, last page.

What's New in EQUIPMENT

Floating Roof

A rigid foam-plastic floating roof designed to reduce evaporation losses from small diameter, fixed-roof tanks storing volatile liquids has been introduced by Hammond Iron Works.

It is expected to find extensive application in gasoline marketing tanks and bulk terminal tanks, solvents storage tanks and other product storage tanks up to 20 feet in diameter. The Hammondflote cover is constructed of rigid polyisocyannate foam —a plastic with exceptionally low density and high load carrying capacity. The cover is made in 18-inch radical sections, each of which is formed in a mold and cured to obtain the required characteristics. The foam structure is composed of an infinite number of closed cells which give the material a high degree of buoyancy. A cubic foot of material weighs three pounds. Cover will remain afloat under all operating conditions.

For more data, circle **No. E1** on Readers' Service Card, last page this issue.

Weather Protected Motors

General Electric announces a new line of NEMA type II vertical weather-protected motors for use in heavy-duty industrial applications.

Designed for year-round use, the motors feature direct blow-through passages, permitting high velocity air to pass through the motor without entering active parts. It also has a series of low velocity air lifts combined with labyrinth turns and baffles to precipitate any moisture or other contaminants before the ventilating air reaches the electrical parts.

(This item supplements General Electric Company data on pages 181-188 of the Pipe Line Composite Catalog, 1st Edition.)

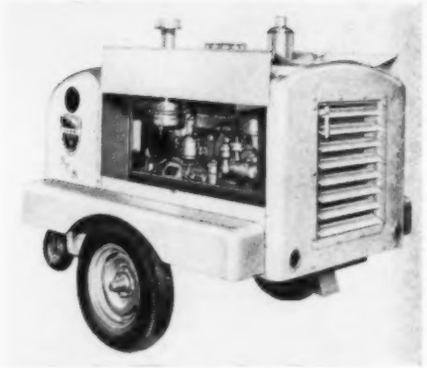
For more data, circle **No. E2** on Readers' Service Card, last page this issue.

Pressure Reducing Valve

Atlas Valve Company announces a high pressure reducing valve for handling large ratio pressure reduction from 6,000 psi initial pressure to outlet pressure from 100 psi upward to within 20 percent of the initial pressure in one stage.

The valve is adapted for air, gas or hydraulic operation. It employs a small air-reducing and relief valve for charging a diaphragm chamber as a means of controlling the reduced pressure.

For more data, circle **No. E3** on Readers' Service Card, last page this issue.



Air Compressor

Le Roi Division, Westinghouse Air Brake Company, introduces its lightest, 2250 pound's and slowest 1,600 rpm, 125 cfm rotary portable air compressor.

Named 125RG2, the compressor is a sliding vane type two stage compressor with an in-line cylinder arrangement. It is powered by direct drive with a Le Roi engine which is a wet sleeve overhead valve engine. The engine compressor is supported on a welded steel frame of unit construction and is enclosed in a lockable steel metal housing.

(This item supplements Le Roi Division of Westinghouse Air Brake Company data on pages 261-264 of the Pipe Line Composite Catalog, 1st Edition.)

For more data, circle **No. E4** on Readers' Service Card, last page this issue.

Galvanometer

Ealing Corporation announces a galvanometer with built-in six-position shunt providing instant varying sensitivity with critical damping.

Dual, curved 150 MM scale is subdivided 0-150 and 75-0-75, permits both deflection and null measurement. Safety shorting switch in rear foot eliminates accidental damage.

For more data, circle **No. E5** on Readers' Service Card, last page this issue.

Diesel Crawler Tractor

International Harvester Company presents a new model diesel crawler tractor, the TD-15. The 105 horsepower six-cylinder engine is noted for its smoothness. It has all-weather, push-button, gasoline conversion starting. Other features include positive valve rotators, pressure lubricated rocker arm shaft, aluminum alloy pistons, fully counter-balanced crankshaft and twin plunger injection system.

The TD-15 is equipped with a six-speed, single stick, full reverse transmission, designed for practical application of all six speed ranges. A shuttle bar control permits instant reverse or forward motion without shifting. Available as optional equipment is a foot decelerator pedal that speeds shifting and makes greater use of exclusive six-speed transmission and shuttle bar.

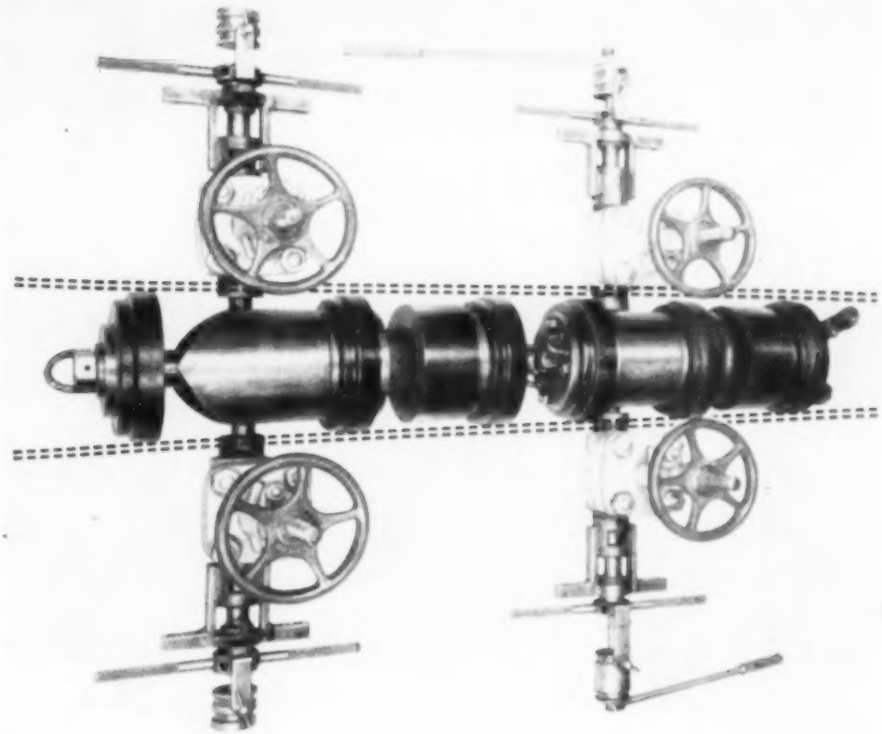
For more data, circle **No. E6** on Readers' Service Card, last page this issue.

Audio Transmitter

Radio Frequency Laboratories, Inc. announces a transistorized audio frequency shift terminal which is capable of transmitting data at speeds up to 250 wpm. Eighteen 100 wpm channels are available from 425 to 3315 cps and six wide band 200 wpm channels from 1615 to 3315.

The plug-in transmitting, receiving, power supply and frequency determining component modules can be arranged for either dual transmitter, dual receiver or transmitter receiver on a single 19½ by 5¼-inch rack mounting chassis. This model 1220 Comtel terminal may be used in telegraph, telemetering and control applications requiring either voltage, current or dry contact keying and is available with either polar relay or electronic receiver outputs.

For more data, circle **No. E7** on Readers' Service Card, last page this issue.

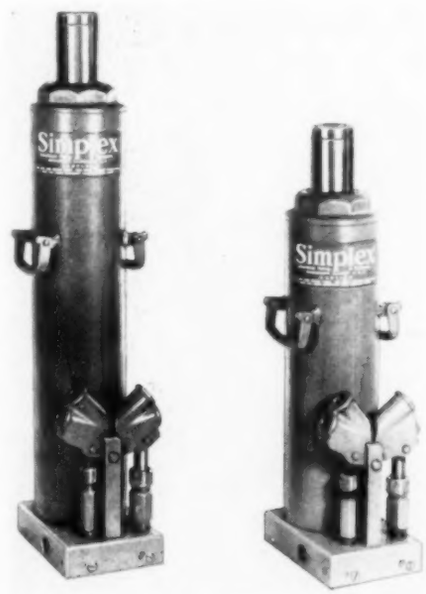


Repair Plugging Pig

MKY P G Pigs Corporation announces a new repair pig which consists of a double pig connected by a universal joint. Couplings are welded outside the line at the ends of the section of pipe to be repaired and holes are drilled through the pipe while under pressure. The pig enters into a trap upstream and normal flow in the line pushes it forward until the rear portion of the double pig reaches the first coupling to the pipe. The rear pig is then locked into position and seals are expanded until the rear pig provides a shut-off at that point.

The front pig is disconnected from the rear one; nitrogen, water or any other inert fluid is injected into the line through the previously tapped hole. The front pig is pushed downstream moving the product ahead of it until it reaches the second coupling. The pig is locked into position, seal expanded and shut-off is provided. The isolated portion of pipe is cut from the line and replaced or repaired in place.

For more data, circle **No. E9** on Readers' Service Card, last page this issue.



Hydraulic Jacks

Templeton, Kenley & Co. has introduced two high lift hydraulic jacks. Equipped with both high and low speed pumps which may be operated separately or in unison, the jacks have a rating capacity of 25 tons.

Model 25H28 has a closed height of 28 inches with a 22-inch lift and weighs 125 pounds; Model 25H22 has a closed height of 22 inches with 16 inches of lift, weighing 105 pounds.

Designed to lift 50 percent over their 25 tons capacity, both may be operated in either vertical or horizontal positions and are equipped with double lever sockets to permit operation in close quarters. The addition of these models increases the line of Simplex hydraulic jacks to 10 models, ranging from 3 to 100 tons capacity.

For more data, circle **No. E8** on Readers' Service Card, last page this issue.

Pipe Leak Clamp

Harris and Wood, Inc., announces development of a one-piece pipe clamp designed for convenience and to save time wherever leaks may develop in pipe. Quick and easy to install, the unit has no separate parts.

It is manufactured from all highly corrosive-resistant material for under or above ground service. Full 360 degree inserts may be furnished in any compressible material according to user's requirements. The clamp can be used on any pipe without danger of crushing or distorting pipe.

For more data, circle **No. E10** on Readers' Service Card, last page this issue.

Air Conditioning

Young Radiator Company announces the availability of its new central station air conditioning units. Vertical, horizontal and multizone types are on the market. Ten sizes with a range of air volume capacity from 700 cfm to 28,000 cfm are available in vertical and horizontal units. Nine sizes and a selection of 2 to 21 zones are available in the multizone type.

Bolting holes between all sections are common, making all sections interchangeable. Servicing has received special attention in the design of these units. Ample access panels and doors have been installed in the various sections to permit easy inspection and service in the field.

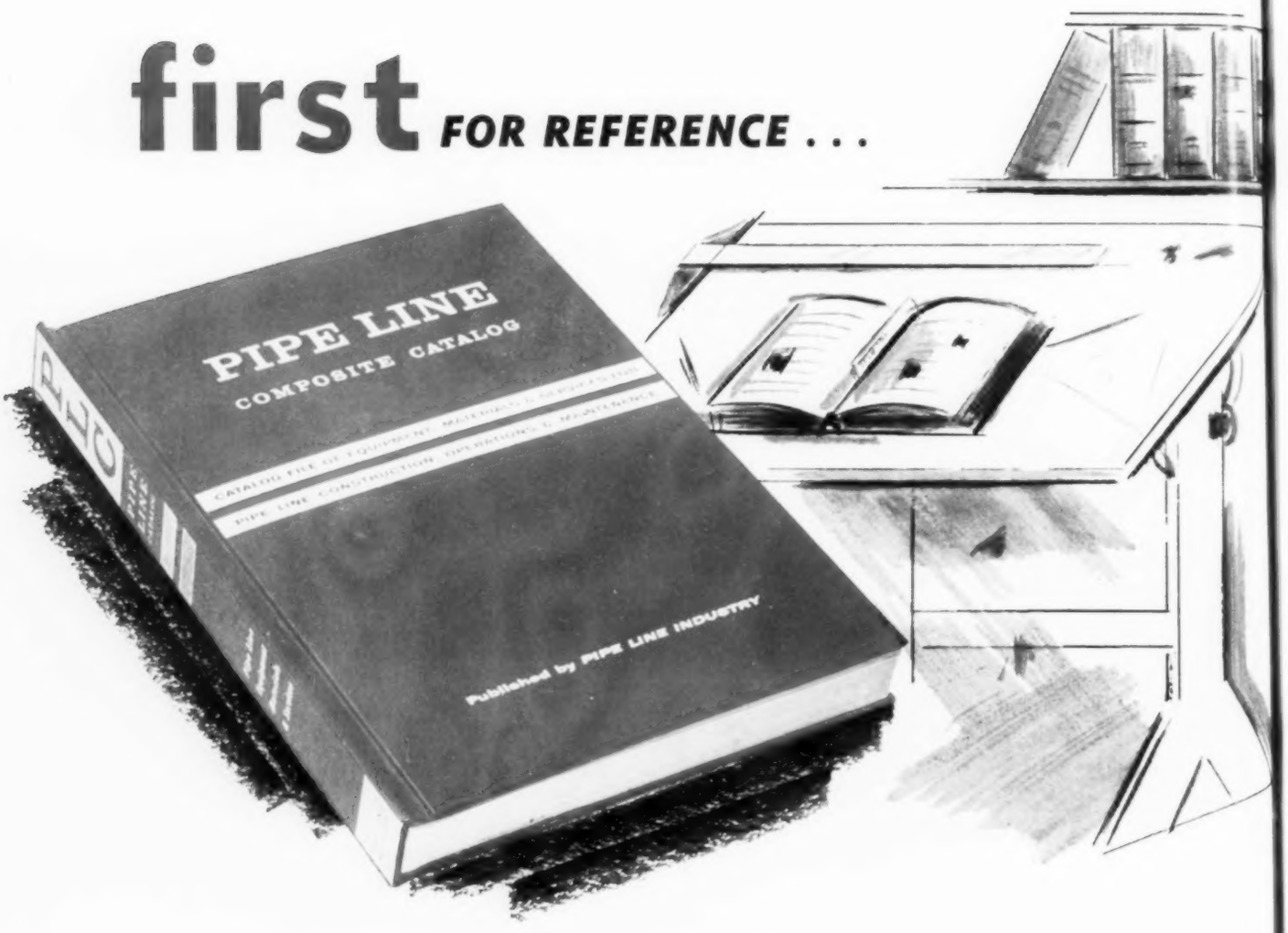
For more data, circle **No. E11** on Readers' Service Card, last page this issue.

Thermo-Drive Actuator

An actuator which utilizes the expansive force of Freon vapor to position valves and other final control elements with precise and repeatable accuracy has been developed by Swartwout Company.

The thermo-drive actuator uses no compressed air, motors, gear trains, pumps, oil, amplifiers, or relays of any kind. The operating principle is based on the controlled rate of heat released through a fluid medium, Freon, circulating in a

first FOR REFERENCE . . .



A *one-volume reference library* for purchasing and specifying. That's the best way to describe the only comprehensive catalog data file published specially for the Pipe Line Industry. Convenient to handle thoroughly indexed, it is saving time and money for thousands of pipe line men.

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Included in 147 equipment and service company data in PLCC, there are 1,627 manufacturers' representatives and sources of supply listed.

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There are 11,148 items of equipment and service items cataloged, with detailed information on specifications, installation, operation, maintenance, service—an entire library of useful reference.

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Pipe Line construction and service items listed in PIPE LINE COMPOSITE CATALOG total 390 . . . an invaluable aid to office and field specifications and purchases.

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When you are ready to buy or specify, or if you just want planning information, look first in PIPE LINE COMPOSITE CATALOG.

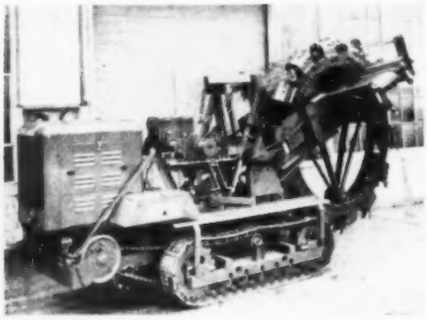
PIPE LINE COMPOSITE CATALOG

Published by PIPE LINE INDUSTRY

P. O. BOX 2608 HOUSTON, TEXAS

closed chamber open only to a condenser. Within the Freon-filled chamber there is a heavy spring bellows coupled to an actuating stem and mechanical position-feedback device. Freon is continuously vaporized by an integral heater creating a vapor pressure within the chamber. Control action is achieved by varying the bleed rate of the Freon into the condenser through a release valve.

For more data, circle **No. E12** on Readers' Service Card, last page this issue.



Wheel-Type Trencher

Cleveland Trencher Company announces a series of trencher models. The model J-20 trencher features a new-type V-shaped discharge conveyor. The V-shaped conveyor provides maximum clearance under the digging wheel rims, allows higher-heaped loads without clogging and passage of larger stones. It also provides a constant angle of elevation for the conveyor, regardless of the position to which the conveyor is shifted. This permits higher and farther spoil discharge and eliminates excessive tumbling and rolling action of the discharge. Extensions are easily added to the conveyor for truck loading and other special spoil handling requirements.

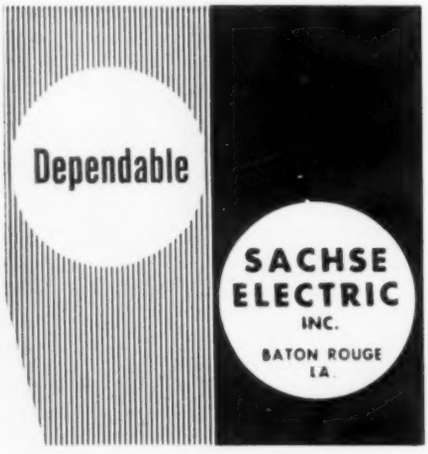
The 190 backfiller, featuring a water-cooled throw-out clutch, is designed for longer life with less maintenance work. The side boom hinges are raised about 18 inches to provide more effective control and accuracy in throw-out and better control of the board in backfilling rocks.

For more data, circle **No. E13** on Readers' Service Card, last page this issue.

Orifice Ring Design

Daniel Orifice Fitting Company announces a design change affecting its junior and senior orifice fittings. Teflon shaft centering rings will be designed to eliminate metal-to-metal contact between shaft and stuffing box. The Teflon rings are self-lubricating, non-adhesive and inert to most chemicals.

For more data, circle **No. E14** on Readers' Service Card, last page this issue.



New Equipment Literature

For more data on New Equipment or copies of Catalogs and Literature reviewed in this issue, use the Reader Service postcards just inside the back cover and facing the Advertisers Index. Simply circle code numbers of items desired—sign and mail card.

Fittings and Flanges

Tube Turns announces publication of a newly revised 48-page catalog of pipe line fittings and flanges. Complete with illustrations and charts, the catalog includes full dimensional data on full-encirclement saddles, anchor forgings, gas distribution fittings, 125 pound light-weight taper-face flanges and 900-pound welding neck, slip-on and blind flanges.

The two-color booklet is divided into sections on Fittings, Flanges, Distribution fittings, technical data and allowable working pressures.

To get a copy, circle **No. E15** on Readers' Service Card, last page this issue.

Automatic Controls

The Cooper-Bessemer Corporation has released a 14-page bulletin on automatic controls for engines and compressors. Titled "En-Tronic Pipeline Control" the four color booklet describes equipment for automatically starting, loading, capacity control, regulating and shutting down pipe line compressors.

This equipment also applies to other types of power machinery such as gas, diesel and gas-diesel engines, as well as motor-driven reciprocating and centrifugal compressors commonly used for gas processing and air services.

To get a copy, circle **No. E16** on Readers' Service Card, last page this issue.

Cement Lining

Centriline Corporation has released a catalog describing a process of in-place centrifugal cement lining of pipes from 4 to 144 inches in diameter. The 20-page catalog features a machine which centrifugally lines pipe as small as 4 inches requiring no excavation at laterals. Also covered are the advantages and developments of Centriline process. It illustrates how the process increases pipe carrying capacity, prevents corrosion in steel and cast iron pipe and is applied at a small fraction of the cost of new pipe.

Sample specifications, test results and case histories of unusual public and industrial projects are also included in the catalog.

To get a copy, circle **No. E17** on Readers' Service Card, last page this issue.

Condulet Breathers, Drains

Crouse-Hinds Company announces availability of a two-page bulletin on condulet breathers and drains which remove moisture from electrical systems.

Type ECD breathers, drains and the new universal breather-drain prevent formation of mildew in explosion proof equipment by ventilating and draining enclosures.

The flier explains how breathers and drains add to the life of explosion-proof electrical equipment.

To get a copy, circle **No. E18** on Readers' Service Card, last page this issue.

Forged Steel Unions

A new simplified catalog, providing complete information on construction of its full line of forged steel unions and union fittings has been issued by Clayton Mark & Co.

Prepared for pipe line crews, contractors and engineers, the 16-page folder contains detailed specifications on Petro, Handlebar, Hydro, Mark and orifice unions, check valves, and forged steel fittings, ranging from 2,000 pounds through 6,000 pounds cwp.

To get a copy, circle **No. E19** on Readers' Service Card, last page this issue.

Ethylene Glycol

Jefferson Chemical Company, Inc. announces a 40-page technical bulletin on the mono-, di-, tri-, and tetra-ethylene glycol.

It presents a comprehensive review of the physical and chemical properties, and industrial uses of the four glycols. It also provides information on methods of shipment, specifications and analytical techniques required for determining product quality and includes an indexed bibliography. Characterized by their water solubility, hygroscopicity, moderate viscosity, and freezing point depression on water, glycols are used for dehydration of gas, antifreeze and explosive formulations, resins, plastics, and plasticizers.

To get a copy, circle **No. E20** on Readers' Service Card, last page this issue.

Wire Rope Slings

A fully illustrated 40-page reference book that covers more than 80 subjects on Tuffy slings and fittings is offered by Union Wire Rope Corporation.

The new edition includes references information condensed into handy chart form on sling types, dimensions and rated loads. The section on Tuffy sling fittings has been expanded to cover many fittings not previously shown, together with reference charts on sizes, rated loads etc.

To get a copy, circle **No. E21** on Readers' Service Card, last page this issue.

Electric Plant

D. W. Onan & Sons Inc., has issued a four-page folder on portable electric plants for construction jobs.

The highly illustrated booklet discusses what should be considered in selecting an electric generating plant. The folder explains that portability and lightness are important considerations.

To get a copy, circle **No. E22** on Readers' Service Card, last page this issue.

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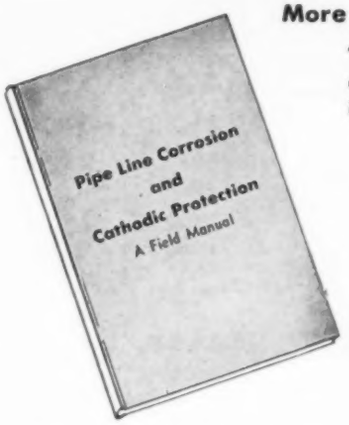
Airline transport rating with commercial privileges on multi & single engine land craft.

5,000 accident-free hours in DC-3's, DC-18's, 310's and Navions. 400 actual instrument hours. U.S.A.F. reserve on flight status. Some sales experience. Salary open. References & complete resume available. Box 51 PLI, PIPE LINE INDUSTRY, Houston, Texas.



More comments on this new Handbook:

"... a most practical on-the-job manual for men concerned with pipe line corrosion. We are ordering copies for each of our district engineers."

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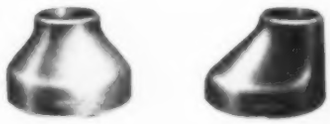

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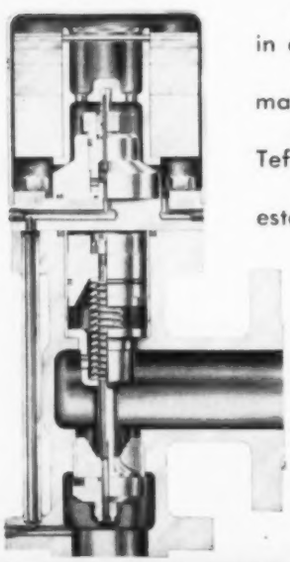

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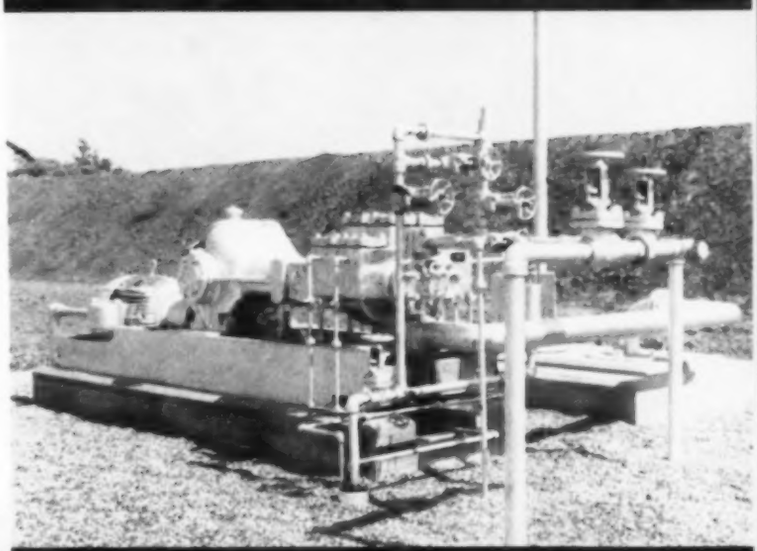

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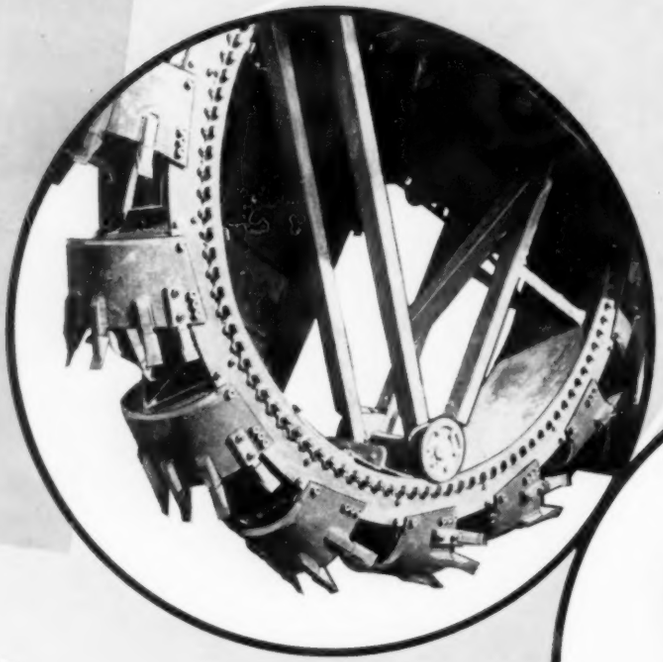

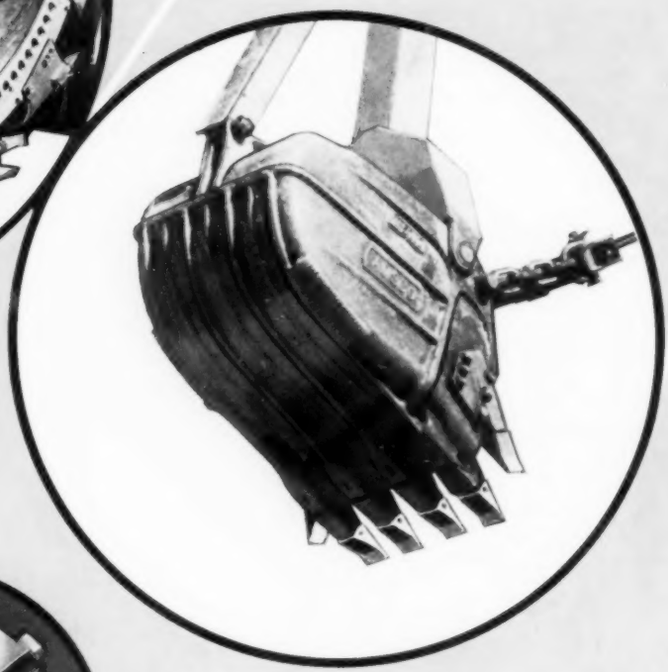

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